THE QUARTERLY REVIEW OF BIOLOGY

JUNE

1954

Vol. 29 No. 2

Published by
THE WILLIAMS & WILKINS COMPANY
BALTIMORE, U. S. A.

Copyright 1954
THE WILLIAMS & WILKINS COMPANY

THE QUARTERLY REVIEW OF BIOLOGY

FOUNDED BY RAYMOND PEARL

B. H. WILLIER, *Editor*
The Johns Hopkins University

H. BENTLEY GLASS
Associate Editor

CARL P. SWANSON
Assistant Editor

Advisory Board

IRVING W. BAILEY.....*Harvard University*
G. W. BEADLE.....*California Institute of Technology*
DAVID R. GODDARD.....*University of Pennsylvania*
ROSS G. HARRISON.....*Yale University*
LIBBIE H. HYMAN.....*American Museum of Natural History*
A. L. KROEBER.....*University of California*
K. S. LASHLEY.....*Harvard University*
CHARLES W. METZ.....*University of Pennsylvania*
THOMAS PARK.....*University of Chicago*
G. H. PARKER.....*Harvard University*
ALFRED S. ROMER.....*Harvard University*
ALEX. G. RUTHVEN.....*University of Michigan*
F. O. SCHMITT.....*Massachusetts Institute of Technology*
PAUL WEISS.....*University of Chicago*

Papers to Appear in an Early Number

MORPHOGENESIS IN PROTOZOA
Paul Weisz, *Brown University*

PHOTOORIENTATION AND THE "TROPISM THEORY"
Harold F. Blum, *National Cancer Institute and Princeton University*

Entered as second-class matter January 27, 1926, at the post office at Baltimore, Maryland, under the act of March 3, 1879.
Subscription price $6.00 a year ($6.50 outside Postal Union) $1.75 a copy.
Made in United States of America

VOL. 29, NO. 2 June, 1954

THE QUARTERLY REVIEW of BIOLOGY

THE POPULATION CONSEQUENCES OF LIFE HISTORY PHENOMENA

BY LAMONT C. COLE

Department of Zoology, Cornell University

PREFACE

FEW branches of biology have attracted more analytical mathematical treatment than has the study of populations. Despite this, one may read in the most complete treatise of ecology yet published (Allee, et al., 1949, p. 271) that "theoretical population ecology has not advanced to a great degree in terms of its impact on ecological thinking." This unfortunate gap between the biologists and the mathematicians has elicited comments which need not be repeated in detail here (Allee, 1934; Gause, 1934; Allee et al., 1949, p. 386). The neglect of the analytical methods by biologists may be attributed in part to the tendency of writers in this field to concentrate on the analysis of human populations and in part to skepticism about the mathematical methods of analysis. Early analyses of population growth (Verhulst, 1838, 1845; Pearl and Reed, 1920) employed human populations as examples, although it is clear from other publications (e.g., Pearl and Miner, 1935; Pearl, 1937) that comparative and general population studies were the principal interest of some of these students. Similarly, the pioneer works of Lotka (1907b, 1910, 1925) were very general in conception but made their greatest impact in the field of demography (Dublin and Lotka, 1925; Dublin, Lotka, and Spiegelman, 1949). The skepticism expressed by biologists toward theoretical studies has ranged from antagonism (Salt, 1936) to approval given with the warning that "... for the sake of brevity and to avoid cumbersome expressions, variables are omitted and assumptions made in the mathematical analyses which are not justified by the biological data" (Allee, 1934). It may be unfortunate that warnings about mathematical oversimplification are especially pertinent in connection with the study of interactions between species (Ross, 1911; Lotka, 1920, 1925; Volterra, 1927, 1931; Nicholson and Bailey, 1935; Thompson, 1939), which is just that portion of the subject which has remained most closely associated with general ecology. Hence we have a situation in which the analytical theories which are recognized by ecologists deal with complex phenomena and are susceptible to cogent criticisms (e.g., Smith, 1952) while the simpler analysis of the ways in which differences between the life histories of species may result in different characteristics of their populations has remained relatively unexplored. It is the purpose of the present paper to consider some parts of this neglected branch of ecology which has been called "biodemography" by Hutchinson (1948).

It is possible, but often impracticable, to compute exactly the characteristics of the hypothetical future population obtained by assuming an unvarying pattern of the pertinent life history features which govern natality and mortality. It is often more practicable to employ approximate methods of computation of the type which have

aroused skepticism among biologists. It will be shown that the two approaches can be reconciled and that for many cases of ecological interest they lead to identical conclusions. Some of these conclusions reached by the writer have appeared surprising when first encountered, and they seem to give a new perspective to life history studies. They also suggest that pertinent bits of information are frequently ignored in life history studies simply because their importance is not generally recognized.

The total life history pattern of a species has meaning in terms of its ability to survive, and ecologists should attempt to interpret these meanings. The following sections are intended primarily to indicate some of the possibilities in this direction. The writer wishes to express his gratitude to Professor Howard B. Adelmann for a critical reading of the manuscript of this paper, for suggesting numerous ways of clarifying the text and improving terminology, and for translating from the Latin parts of the text from Fibonacci (1202). Thanks are also due to Professors Robert J. Walker and Mark Kac who have been consulted about technical mathematical questions raised by the writer while considering various phases of this subject.

INTRODUCTION

If it is to survive, every species must possess reproductive capacities sufficient to replace the existing species population by the time this population has disappeared. It is obvious that the ability of the ancestors of existing species to replace themselves has been sufficient to overcome all environmental exigencies which have been encountered and, therefore, that the physiological, morphological, and behavioral adaptations that enable offspring to be produced and to survive in sufficient numbers to insure the persistence of a species are of fundamental ecological interest.

On the other hand, it is conceivable that reproductive capacity might become so great as to be detrimental to a species. The many deleterious effects of overcrowding are well known. It also seems obvious that a species which diverts too large a proportion of its available energies into unnecessary, and therefore wasteful, reproduction would be at a disadvantage in competition with other species.

In this paper it will be regarded as axiomatic that the reproductive potentials of existing species are related to their requirements for survival; that any life history features affecting reproductive potential are subject to natural selection; and that such features observed in existing species should be considered adaptations, just as purely morphological or behavioral patterns are commonly so considered.

Some of the more striking life history phenomena have long been recognized as adaptations to special requirements. The great fecundity rather generally found in parasites and in many marine organisms is commonly regarded as an adaptation insuring the maintenance of a population under conditions where the probability is low that any particular individual will establish itself and reproduce successfully. Again, parthenogenesis obviously favors the rapid growth of a population because every member of a population reproducing in this fashion can be a reproductive female. In turning seasonally to parthenogenesis, organisms like cladocerans and aphids are responding in a highly adaptive way during a limited period of time when the environmental resources are sufficient to support a large population. Parthenogenesis, hermaphroditism, and purely asexual reproduction may clearly offer some advantages under conditions that restrict the probability of contacts between the sexes. Protandry, as exhibited, for example, by some marine molluscs, and various related phenomena where population density affects the sex ratio (Allee et al., 1949, p. 409) may be considered as compromise devices providing the advantages of biparental inheritance while maintaining an unbalanced sex ratio which makes most of the environmental re-resources available to reproductive females.

Reproductive potentialities may be related to the success of a species in still other ways. It was an essential part of Darwin's thesis that the production of excess offspring provided a field of heritable variations upon which environmental conditions could operate to select the most favorable combinations. A high degree of fecundity may also aid the dispersal of species. An extreme example of this is afforded by the ground pine, *Lycopodium* (Humphreys, 1929), whose light windborne spores may be scattered literally over the whole face of the earth and so make it likely that all favorable habitats will come to be occupied. Another adaptational interpretation of the overproduction of offspring postulates that the excessive production of young fish which are frequently cannibalistic is a form of maternal provisioning,

the majority of the young serving merely as food for the few that ultimately mature.

Many additional examples of life history phenomena that have been regarded as adaptive could be cited. Here, however, we wish rather to call attention to the striking fact that in modern ecological literature there have been relatively few attempts to evaluate quantitatively the importance of specific features of life histories. The apparent mathematical complexity of the general problem is undoubtedly partly responsible for this. When the biologist attempts to compute from observed life history data the numbers of organisms of a particular type that can be produced in a given interval of time he may find it necessary to make assumptions which biologists in general would hesitate to accept. And even with these simplifying assumptions the computations may become so tedious as to make the labor involved seem unjustifiable in view of the seemingly academic interest of the result. In particular, such computations involve biological parameters which are not necessarily fixed characteristics of the species and which are not ordinarily expressible in convenient mathematical form. It is necessary to know the way in which the chance of dying (or of surviving) and the reproductive activities vary during the life span of an individual. These quantities are nicely summed up by the familiar life-table function, survivorship (l_x), which is defined as the probability of surviving from birth to some age x, and by the age-specific birth rate (b_x), which is defined as the mean number of offspring produced during the interval of age from age x to age $x + 1$. The biologist immediately recognizes that these quantities vary with environmental conditions and that he cannot expect to obtain a realistic result if he must assume, for example, that the probability of surviving a day, a week, or a month, is the same for individuals born in the autumn as for those born in the spring. He also recognizes that the population consists of discrete units and that offspring are produced in batches (here called litters whether in plants or animals) rather than continuously; hence he necessarily regards with suspicion any formulation of the problem in terms of differential equations where these considerations are apparently ignored.

Actually a tremendous variability is observed in life history phenomena which could affect the growth of populations. Some organisms are semelparous, that is to say, they reproduce only once in a lifetime and in these semelparous forms reproduction may occur at the age of only 20 minutes in certain bacteria (Molisch, 1938), of a few hours in many protozoa, or of a few weeks or months in many insects. Many semelparous plants and animals are annuals; in other semelparous organisms reproduction may occur only after a number of years of maturation, for example, two or more years in dobson flies and Pacific salmon, and many years in "century plants" (*Agave*) and the periodic cicada or "17-year locust" (*Magicicada septendecim*). The number of potential offspring produced by semelparous individuals varies from two in the case of binary fission to the literally trillions (2×10^{13}) of spores produced by a large puffball (*Calvatia gigantea*).

In iteroparous forms, that is to say, those which reproduce more than once in a lifetime, the period of maturation preceding the first production of prospective offspring may vary from as little as a few days in small crustaceans to over a century in the giant sequoia (U. S. Forest Service, 1948), and practically any intermediate value may be encountered. After the first reproduction has occurred in iteroparous organisms it may be repeated at various intervals—for example, daily (as in some tapeworms), semiannually, annually, biennially, or irregularly (as in man). As in semelparous organisms, the litter size of iteroparous forms may also vary greatly; here it may vary from one (as is usual, for example, in man, whales, bovines, and horses) to many thousands (as in various fishes, tapeworms, or trees). The litter size may be constant in a species, vary about some average, or change systematically with the age of the parent, in which case it may increase to some maximum (as in tapeworms) or climb to a maximum and then decline as in some cladocerans (Banta et al., 1939; Frank, 1952). Furthermore, individuals may live on after their reproduction has ceased completely, and this post-reproductive period may amount to more than one-half of the normal life span (Allee et al., 1949, p. 285).

There is similar variability in the potential longevity of individual organisms. Man, various turtles, and trees may survive more than a century, while, on the other hand, the life span of many other species is concluded in hours or days. Innumerable intermediate values of course occur.

Additional sources of variation (such as biased sex ratios and the occurrence of asexual reproduction in developmental stages so as to result in the

production of many offspring from one egg or spore) force the conclusion that the number of theoretical combinations of observed life history phenomena must greatly exceed the number of known species of organisms. And if all these phenomena have potential adaptive importance the interpretation of the possible merits of the particular combination of features exhibited by a species presents a problem of apparent great complexity.

The usual mathematical approach to the problem of potential population growth is straightforward. It is assumed that the growth of a population at any instant of time is proportional to the size of the population at that instant. If r is the factor of proportionality and P_x represents the population size at any x time this leads to the differential equation

$$\frac{dP}{dx} = rP \qquad (1)$$

which upon integration gives:

$$P_x = Ae^{rx} \qquad (1')$$

where A is a constant. This is an equation of continuous compound interest at the rate r or of a geometric progression where the ratio between the sizes of the populations in two consecutive time intervals, say years, is e^r.

While formulas (1) and (1′) represent only the usual starting point for mathematical discussions of population growth, they already exhibit points about which there has been, and still is, a great deal of controversy. Explicit statements to the effect that human populations potentially increase by geometric progression can be traced back at least to Capt. John Graunt (1662), who estimated that a human population tends to double itself every 64 years (which would correspond to $r = .0108$ in formula 1). This belief in geometric progression as the form of potential population increase was endorsed by numerous students prior to the great controversy initiated by Malthus in 1798 (see review by Stangeland, 1904). Among these early writers we may here note only Linnaeus (1743), who considered the problem of geometric increase in the progeny of an annual plant, and Benjamin Franklin (1751), who estimated that the population of "America" could double at least every 20 years (corresponding to $r = .035$), and who clearly regarded the geometric nature of potential population increase as a general organic phenomenon.

The great controversy over growth in human populations which was initiated by the publication in 1798 of Malthus' *Essay on Population* engendered numerous arguments regarding geometric progression as the potential form of population growth. This controversy is still alive and in much its original form, with the "Neo-Malthusian" position maintaining that potential population growth is indeed in the form of a geometric progression, whereas the capacity of the environment to absorb population is necessarily limited, and with their opponents denying both the geometric progression and the finite capacity of the environment. Essentially the modern arguments against the Malthusian thesis, although not presented in modern concise form, are to be found in the treatise by Sadler (1830) which, whatever its shortcomings from the modern point of view, contains in places (especially in the appendix to Book IV) a very remarkable pre-Darwinian statement of such ecological phenomena as food chains, species interactions, and the balance of numbers between predators and prey.

The entire problem of potential population growth and its relationship to the resources of the environment is clearly one of the fundamental problems of ecology, but one which has never been adequately summarized in a way to reconcile the mathematical approaches, such as those of Lotka (1925), Volterra (1927), Kuczynski (1932, 1935), Kostitzin (1939), and Rhodes (1940), and the purely biological approaches which have concentrated on life history features such as longevity, fecundity, fertility, and sex ratios. In the present paper we will consider the mathematical form of potential population growth and certain subsidiary phenomena and the way in which these are related to particular life history phenomena. It is hoped that this will bring to attention some of the possible adaptive values of observed life history phenomena and will lead ecologists to a greater consideration of population problems which are essentially ecological. Life history features do in fact control potential population growth, as Sadler recognized, but the quantitative relationships have still been so insufficiently elucidated that even today ecologists generally do not attempt to answer queries such as the following, written by Sadler in 1830 (Vol. 2, p. 318):

"For instance, how would those who have the folly to suppose that population in this country advances too fast by one per cent., so operate, had they even

their wish, as to diminish the number of marriages by one in one hundred, or otherwise contract the fecundity of the existing number by about one twenty-fifth part of a birth each, or calculate, upon their own erroneous suppositions, the term of that postponement of marriage on which they insist so much, so as to produce this exact effect? The very idea is, in each instance, absurd to the last degree."

FUNDAMENTAL CONSIDERATIONS

Sadler (1830) makes clear in numerous places his belief that "... the geometrical ratio of human increase is, nevertheless, in itself, an impossibility ..." (Vol. 2, p. 68). However, when one examines his argument it is apparent that he is not actually opposing the principle that with fixed life history features populations would grow at compound interest, but rather is proposing the thesis that life history features change with population density, e.g., his fundamental thesis: "The prolificness of human beings, otherwise similarly circumstanced, varies inversely as their numbers" (Vol. 2, p. 252). Some of Sadler's computations assuming fixed ages at marriage and fecundity rates, in fact, lead to geometric progressions.

The modern conception of population growth regards the *potential* rate of increase as a more or less fixed species characteristic (cf. Chapman, 1935) governed by life history features; but it considers that this potential rate is ordinarily only partially realized, the "partial potential" characteristic of a particular situation being dependent on environmental conditions. Ecologists commonly associate this concept of "biotic potential" with the name of Chapman (1928, 1935), but actually the concept of populations as systems balanced between a potential ability to grow and an "environmental resistance" dates back at least to the Belgian statistician Quetelet (1835), who considered (p. 277) that potential population growth is a geometric progression, while the resistance to population growth (by analogy with a body falling through a viscous medium) varies as the square of the rate of growth. Only three years later Quetelet's student and colleague Verhulst (1838) set forth the thoroughly modern concept that potential population growth is a geometric progression corresponding to our formula (1′), and that the environmental resistance varies inversely with the unexploited opportunities for growth. By this conception, if K represents the capacity of the environment or the ultimate size which the population can attain, the resistance to population growth increases as $K - P$, the amount of space remaining to be occupied, decreases. As the simplest case Verhulst considered that the resistance is related in a linear manner to the remaining opportunities for growth and thus derived the familiar logistic function as a representation of population growth (for discussion see Allee et al., 1949).

The modern mathematical formulation of population growth, as given, for example, by Rhodes (1940), proceeds by expressing the environmental resistance as some function of population size, $f(P)$, and writing a differential equation of the type

$$\frac{dP}{dx} = rPf(P). \tag{2}$$

By employing different functions for $f(P)$, any number of population growth laws may be derived and the mathematical connection between P and x determined, providing equation (2) can be integrated. Rhodes gives several examples of the procedure.

Formula (1′), the equation of the geometric progression representing population growth in an unlimited environment, represents the special case of formula (2) where the factor $f(P)$ is replaced by a constant, most conveniently by the constant value unity. By the foregoing interpretation it is clear that the constant r must be regarded as a quantity of fundamental ecological significance. It is to be interpreted as the rate of true compound interest at which a population would grow if nothing impeded its growth and if the age-specific birth and death rates were to remain constant.

Quite recently a number of ecologists have recognized the importance of a knowledge of the value of r for non-human populations and have computed its value for various species by employing empirical values of age-specific birth rates and survivorship (Leslie and Ranson, 1940; Birch, 1948; Leslie and Park, 1949; Mendes, 1949; Evans and Smith, 1952). While Chapman's term "biotic potential" would seem to have ecological merit as the name for this parameter r it has been variously called by Lotka the "true," the "incipient," the "inherent," and the "intrinsic" rate of increase, and by Fisher (1930) the "Malthusian parameter" of population increase. Probably for the sake of stabilizing nomenclature it is advisable to follow the majority of recent writers and refer to r as "the intrinsic rate of natural increase."

In the works of Dublin and Lotka (1925),

Kuczynski (1932), and Rhodes (1940) on human populations and in the papers mentioned above dealing with other species, the value of r has typically been determined by some application of three fundamental equations developed by Lotka (1907a, b; Sharpe and Lotka, 1911). He showed that if the age-specific fecundity (b_x) and survivorship (l_x) remained constant, the population would in time assume a fixed or "stable" age distribution such that in any interval of age from x to $x + dx$ there would be a fixed proportion (c_x) of the population. Once this stable age distribution is established the population would grow exponentially according to our formula (1′) and with a birth rate per head, β. Then the following equations relate these quantities:

$$\int_0^\infty e^{-rx} l_x b_x \, dx = 1 \tag{3}$$

$$\int_0^\infty e^{-rx} l_x \, dx = 1/\beta \tag{4}$$

and

$$\beta e^{-rx} l_x = c_x. \tag{5}$$

While the use of formulas (3), (4), and (5) to compute the value of r often presents practical difficulties owing to the difficulty of approximating the functions l_x and b_x by a mathematical function, and also because the equations usually must be solved by iterative methods, it may fairly be stated that Lotka's pioneer work establishing these relationships provided the methods for interpreting the relationships between life history features and their population consequences.

However, the exceedingly important ecological questions of what potential advantages might be realized if a species were to alter its life history features have remained largely unexplored. Doubtless, as already noted, this is largely to be explained by a certain suspicion felt by biologists toward analyses such as those of Lotka, which seem to involve assumptions very remote from the realities of life histories as observed in the field and laboratories. A particularly pertinent statement of this point of view is that of Thompson (1931), who recognized the great practical need for methods of computing the rate of increase of natural populations of insects adhering to particular life history patterns but who insisted that the reproductive process must be dealt with as a discontinuous phenomenon rather than as a compound interest phenomenon such as that of formula (1′). His methods of computation were designed to give the exact number of individuals living in any particular time period and, while he recognized that the population growth can be expressed in an exponential form such as (1′), he rejected its use on these grounds:

> "In the first place, the constant (r) cannot be determined until the growth of the population under certain definite conditions has been studied during a considerable period; in the second place, no intelligible significance can be attached to the constant after its value has been determined; in the third place, the growth of the population is considered in this formula to be at every moment proportional to the size of the population, which is not true except with large numbers and over long periods and cannot be safely taken as a basis for the examination of experimental data."

In the following sections of the present paper an effort will be made to reconcile these two divergent points of view and to show under what conditions Thompson's "discontinuous" approach and the continuous methods lead to identical results. Practical methods of computation can be founded on either scheme, and there are circumstances where one or the other offers distinct advantages. It is hoped that a theoretical approach to population phenomena proceeding from exact computational methods will clarify the meaning of some of the approximations made in deriving equations such as (3), (4), and (5) by continuous methods, and will stimulate students of ecology to a greater interest in the population consequences of life history phenomena.

Before proceeding to a discussion of potential population growth, one point which has sometimes caused confusion should be mentioned. This concerns the sex ratio and the relative proportions of different age classes in the growing population. Once stated, it is obvious that if a population is always growing, as are the populations in the models used for determining potential population growth, then each age and sex class must ultimately come to grow at exactly the same rate as every other class. If this were not the case the disproportion between any two classes would come to exceed all bounds; the fastest growing class would continue indefinitely to make up a larger and larger proportion of the total population. It is thus intuitively recognizable that with fixed life history features there must ultimately be a fixed sex ratio and a stable age distribution. In discussing potential population growth it is often convenient to confine our attention to females or

even to a restricted age class, such as the annual births, while recognizing that the ultimate growth rate for such a restricted population segment must be identical to the rate for the entire population.

SIMPLEST CASES OF POPULATION GROWTH

Non-overlapping generations

The simplest possible cases of population growth from the mathematical point of view are those in which reproduction takes place once in a lifetime and the parent organisms disappear by the time the new generation comes on the scene, so that there is no overlapping of generations. This situation occurs in the many plants and animals which are annuals, in those bacteria, unicellular algae, and protozoa where reproduction takes place by fission of one individual to form two or more daughter individuals, and in certain other forms. Thus in the century plants (*Agave*) the plant dies upon producing seeds at an age of four years or more, the Pacific salmon (*Oncorhynchus*) dies after spawning, which occurs at an age of two to eight years (two years in the pink salmon *O. gorbuscha*), and cicadas breed at the end of a long developmental period which lasts from two years (*Tibicen*) to 17 years in *Magicicada*. For many other insects with prolonged developmental stages such as neuropterans and mayflies potential population growth may be considered on the assumption that generations do not overlap.

In these cases, perhaps most typically illustrated in the case of annuals, the population living in any year or other time interval is simply the number of births which occurred at the beginning of that interval. Starting with one individual which is replaced by b offspring each of which repeats the life history pattern of the parent, the population will grow in successive time intervals according to the series: $1, b, b^2, b^3, b^4, \cdots b^x$. Hence the number of "births," say B_x, at the beginning of any time interval, T_x, is simply b^x which is identical with the population, P_x, in that interval of time. If the population starts from an initial number P_0 we have:

$$P_x = P_0 b^x \qquad (6)$$

which is obviously identical with the exponential formula (1′), $P_x = Ae^{rx}$, where the constant A is precisely P_0, the initial population size, and $r = \ln b$; the intrinsic rate of increase is equal to the natural logarithm of the litter size.

If litter size varies among the reproductive individuals, with each litter size being characteristic of a fixed proportion of each generation, it is precisely correct to use the average litter size, say $\bar{b}$, in the computations, so that we have $r = \ln \bar{b}$. Furthermore, if not all of the offspring are viable, but only some proportion, say l_1, survive to reproduce, we shall have exactly $r = \ln \bar{b}l_1$. Thus, mortality and variations in litter size do not complicate the interpretation of population growth in cases where the generations do not overlap. On the other hand, even in species which reproduce only once, if the generation length is not the same for all individuals, this will lead to overlapping generations, and the simple considerations which led to formula (6) will no longer apply. In other words, we can use an average figure for the litter size b but not for the generation length x. It will be shown in the next section, however, that the more general formula (1′) is still applicable.

In these simplest cases the assumption of a geometric progression as the potential form of population growth is obviously correct, and numerous authors have computed the fantastic numbers of offspring which could potentially result from such reproduction. For example, according to Thompson (1942), Linnaeus (1740?) pointed out that if only two seeds of an annual plant grew to maturity per year, a single individual could give rise to a million offspring in 20 years. (In all editions available to the present writer this interesting essay of Linnaeus' is dated 1743, and the number of offspring at the end of twenty years is stated by the curious and erroneous figure 91,296.) That is, $P_{20} = 2^{20} = e^{20 \ln 2} = 1{,}048{,}576$. Additional examples are given by Chapman (1935, p. 148).

Formulas (1′) or (6) may, of course, also be used in an inverse manner to obtain the rate of multiplication when the rate of population growth is known. For the example given by Molisch (1938, p. 25), referring to diatoms reproducing by binary fission where the average population was observed to increase by a factor of 1.2 per day, we have $1.2 = e^{x \ln 2}$, where x is the number of generations per day. Solving for $1/x$, the length of a generation, we obtain $1/x = \dfrac{\ln 2}{\ln 1.2} = \dfrac{.69315}{.18232} = 3.8$ days.

Overlapping generations

Interest in computing the number of offspring which would be produced by a species adhering to a constant reproductive schedule dates back at

least to Leonardo Pisano (=Fibonacci) who, in the year 1202, attempted to reintroduce into Europe the study of algebra, which had been neglected since the fall of Rome. One of the problems in his *Liber Abbaci* (pp. 283–84 of the 1857 edition) concerns a man who placed a pair of rabbits in an enclosure in order to discover how many pairs of rabbits would be produced in a year. Assuming that each pair of rabbits produces another pair in the first month and then reproduces once more, giving rise to a second pair of offspring in the second month, and assuming no mortality, Fibonacci showed that the number of pairs in each month would correspond to the series

1, 2, 3, 5, 8, 13, 21, 34, 55, etc.,

where each number is the sum of the two preceding numbers. These "Fibonacci numbers" have a rather celebrated history in mathematics, biology, and art (Archibold, 1918; Thompson, 1942; Pierce, 1951) but our present concern with them is merely as a very early attempt to compute potential population growth.

Fibonacci derived his series simply by following through in words all of the population changes occurring from month to month. One with sufficient patience could, of course, apply the same procedure to more complicated cases and could introduce additional variables such as deductions for mortality. In fact, Sadler (1830, Book III) did make such computations for human populations. He was interested in discovering at what ages persons would have to marry and how often they would have to reproduce to give some of the rates of population doubling which had been postulated by Malthus (1798). To accomplish this, Sadler apparently employed the amazingly tedious procedure of constructing numerous tables corresponding to different assumptions until he found one which approximated the desired rate of doubling.

Although we must admire Sadler's diligence, anyone who undertakes such computations will find that it is not difficult to devise various ways of systematizing the procedure which will greatly reduce the labor of computation. By far the best of these methods known to the present writer is that of Thompson (1931), which was originally suggested to him by H. E. Soper.

In the Soper-Thompson approach a "generation law" (G) is written embodying the fixed life history features which it is desired to consider. The symbol T^x stands for the x^{th} interval of time, and a generation law such as $G = 2T^1 + 2T^2$ would be read as "two offspring produced in the first time interval and two offspring produced in the second time interval." This particular generation law might, for example, be roughly applicable to some bird such as a cliff swallow, where a female produces about four eggs per year. Concentrating our attention on the female part of the population, we might wish to compute the rate of population growth which would result if each female had two female offspring upon attaining the age of one year and had two more female offspring at the age of two years. The fundamental feature of the Thompson method is the fact that the expression:

$$\frac{1}{1 - G} \tag{7}$$

is a generating function which gives the series of births occurring in successive time intervals. In the algebraic division the indices of the terms T^1, T^2, etc., are treated as ordinary exponents and the number of births occurring in any time interval T^x is simply the coefficient of T^x in the expansion of expression (7). Thus, for our example where $G = 2T^1 + 2T^2$ we obtain:

$$\frac{1}{1 - 2T^1 - 2T^2} = 1 + 2T^1 + 6T^2 + 16T^3 + 44T^4 + 120T^5 + 328T^6 + \cdots,$$

showing that one original female birth gives rise to 328 female offspring in the sixth year. The series could be continued indefinitely to obtain the number of births any number of years hence. However, in practice it is not necessary to continue the division. In the above series the coefficient of each term is simply twice the sum of the coefficients of the two preceding terms; hence the generation law gives us the rule for extending the series. $G = 2T^1 + 2T^2$ instructs us to obtain each new term of the series by taking twice the preceding term plus twice the second term back. In the case of the Fibonacci numbers we would have $G = T^1 + T^2$, telling us at once that each new term is the sum of the two preceding it.

From the birth series we can easily obtain the series enumerating the total population. If each individual lives for λ years, the total population in T^x will be the sum of λ consecutive terms in the expansion of the generating function. Multiplying formula (7) by the length of life expressed in the form $1 + T^1 + T^2 + T^3 + \cdots + T^{\lambda-1}$ will give

the population series. In our above example if we assume that each individual lives for three years, although, as before, it only reproduces in the first two, we obtain for the population

$$\frac{1 + T^1 + T^2}{1 - 2T^1 - 2T^2} = 1 + 3T^1 + 9T^2 + 24T^3 + 66T^4 + 180T^5 + 492T^6 + \cdots,$$

a series which still obeys the rule $G = 2T^1 + 2T^2$.

Thompson's method for obtaining the exact number of births and members of the population in successive time intervals is very general. As in the case of non-overlapping generations, the coefficients in the generation law may refer to average values for the age-specific fecundity. Also the length of the time intervals upon which the computations are based can be made arbitrarily short, so that it is easy to take into account variations in the age at which reproduction occurs. For the above example, time could have been measured in six-month periods rather than years so that the generation law would become $G = 2T^2 + 2T^4$, with the same results already obtained.

Furthermore, the factor of mortality can easily be included in the computations. For example, suppose that we wish to determine the rate of population growth for a species where the females have two female offspring when they reach the age of one, two more when they reach the age of two, and two more when they reach the age of three. Neglecting mortality, this would give us the generation law $G = 2T^1 + 2T^2 + 2T^3$. If we were further interested in the case where not all of the offspring survive for three years, the coefficients in the generation law need only be multiplied by the corresponding survivorship values. For example, if one-half of the individuals die between the ages of one and two, and one half of the remainder die before reaching the age of three we would have $l_1 = 1$, $l_2 = \frac{1}{2}$, $l_3 = \frac{1}{4}$, and the above generation law would be revised to $G = 2T^1 + T^2 + \frac{1}{2}T^3$. The future births per original individual would then be

$$\frac{1}{1 - G} = 1 + 2T^1 + 5T^2 + 25/2T^3 + 31T^4 + 151/2T^5 + \cdots.$$

Very generally, if the first reproduction for a species occurs at some age α and the last reproduction occurs at some age ω, and letting b_x and l_x represent respectively the age-specific fecundity and survivorship, we may write the generation law as:

$$G = l_\alpha b_\alpha T^\alpha + l_{\alpha+1} b_{\alpha+1} T^{\alpha+1} + \cdots + l_\omega b_\omega T^\omega = \sum_{x=\alpha}^{\omega} l_x b_x T^x. \tag{8}$$

Therefore, in the Thompson method we have a compact system of computation for obtaining the exact number of births and the exact population size at any future time, assuming that the significant life history features (α, ω, l_x, and b_x) do not change.

Not all of the possible applications of Thompson's method have been indicated above. For example, formula (7) may be used in an inverse manner so that it is theoretically possible to work back from a tabulation of births or population counts made in successive time intervals and discover the underlying generation law. Formulas (7) and (8), together with the procedure of multiplying the birth series by the length of life expressed as a sum of T^x values, provide the nucleus of the system and offer the possibility of analyzing the potential population consequences of essentially any life-history phenomena. The system has the merit of treating the biological units and events as discontinuous variates, which, in fact, they almost always are. The members of populations are typically discrete units, and an event such as reproduction typically occurs at a point in time with no spreading out or overlapping between successive litters. While survivorship, l_x, as a population quantity, is most realistically regarded as continuously changing in time, the product $l_x b_x$ which enters our computations by way of formula (8) is typically discontinuous because of the discontinuous nature of b_x.

It is quite obvious that equations of continuous variation such as (1′) are often much more convenient for purposes of computation than the series of values obtained by expanding (7). This is especially true in dealing with the life histories of species which have long reproductive lives. In writing a generation law for man by (8) we should have to take α at least as small as 15 years and ω at least as great as 40 years, since for the population as a whole reproduction occurs well outside of these extremes and it would certainly be unrealistic to regard b_x as negligibly small anywhere between these limits. Thus there would be at least 25 terms in our generation law, and the computations would be extremely tedious. By selecting special cases

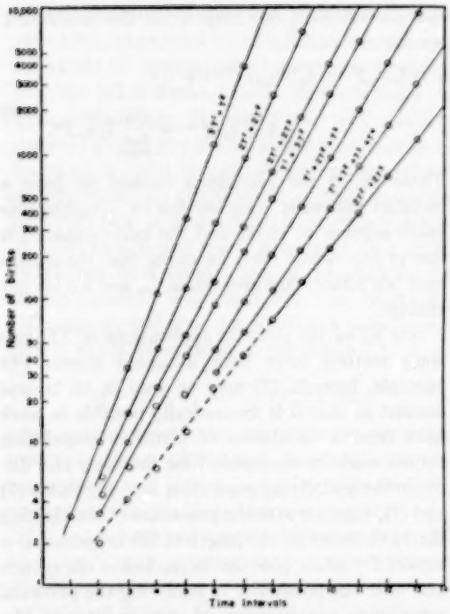

FIG. 1. EXACT VALUES OF POPULATION GROWTH IN TERMS OF BIRTHS PER UNIT TIME UNDER SEVERAL GENERATION LAWS, WHEN EACH FEMALE HAS A TOTAL OF FOUR FEMALE OFFSPRING

In each case it is assumed that a single female exists at time zero and produces her four progeny on or before her fourth birthday. The plotted points represent exact values as determined by Thompson's method. To the extent that the points for any generation law fall on a straight line in this logarithmic plot, they can be represented by the exponential growth formula (1′), and the slope of each line is a measure of the intrinsic rate of natural increase (r).

for study it is sometimes possible greatly to simplify the procedures. For example, if one is interested in the case where there is no mortality during the reproductive span of life and where the litter size is a constant, say b, the expression for the generation law (8) can be simplified to:

$$G = bT^{\alpha} + bT^{\alpha+1} + \cdots bT^{\omega} = \frac{bT^{\alpha} - bT^{\omega+1}}{1 - T}.$$

Since one can also write the length of life as

$$1 + T^{1} + T^{2} + \cdots + T^{\lambda-1} = \frac{1 - T^{\lambda}}{1 - T},$$

the generating function for the total population simplifies to

$$\frac{1 - T^{\lambda}}{1 - T - bT^{\alpha} + bT^{\omega+1}}.$$

This last formula is much more convenient for computations than one containing 25 terms or so in the denominator, but it applies only to a very special case and is much less convenient than formula (1′). Consequently, great interest attaches to these questions: can (1′) be used as a substitute for (7)? (i.e., does Thompson's method lead to a geometric progression?) and, if it is so used, can the constants, particularly r, be interpreted in terms of life-history features?

THE GENERALIZATION OF THOMPSON'S METHOD

Fig. 1 shows the exact values, as determined by Thompson's method, of the birth series arising from several generation laws (life-history patterns) which have in common the feature that in each case every female produces a total of four female offspring in her lifetime and completes her reproductive life by the age of four "years." The number of births is plotted on a logarithmic scale, hence if it can be represented by formula (1′), $P = Ae^{rx}$ or, logarithmically, $\ln P = \ln A + rx$, the points should fall on a straight line with slope proportional to r. It is apparent from Fig. 1 that after the first few time intervals the points in each case are well represented by a straight line. Therefore, except in the very early stages, formula (1′) does give a good representation of potential population growth. The question remains, however, as to whether we can meet Thompson's objection to (1′) and attach any intelligible significance to the constants of the formula. From Fig. 1 it is obvious that the lines do not, if projected back to time 0, indicate exactly the single individual with which we started. Thus, in these cases the constant A cannot be precisely P_0 as was the case with non-overlapping generations.

Before proceeding to interpret the constants of formula (1′) for the case of overlapping generations it will be well to notice one feature of Fig. 1 which is of biological interest. In the literature of natural history one frequently encounters references to the number of offspring which a female can produce per lifetime, with the implication that this is a significant life-history feature. The same implication is common in the literature dealing with various aspects of human biology, where great emphasis is placed on the analysis of total family size. From Fig. 1 it will be seen that this datum may be less significant from the standpoint of contributions to future population than is the age schedule upon which these offspring are

produced. Each life history shown in Fig. 1 represents a total production of four offspring within four years of birth, but the resulting rates of potential population growth are very different for the different schedules. It is clear that the cases of most rapid population growth are associated with a greater concentration of reproduction into the early life of the mother. This is intuitively reasonable because we are here dealing with a compound interest phenomenon and should expect greater yield in cases where "interest" begins to accumulate early. However, the writer feels that this phenomenon is too frequently overlooked in biological studies, possibly because of the difficulty of interpreting the phenomenon quantitatively.

In seeking to reconcile the continuous and discontinuous approaches to potential population growth, let us first note that Thompson's discontinuous method corresponds to an equation of finite differences. We have seen above that the generation law gives us a rule for indefinitely extending the series representing the population size or the number of births in successive time intervals by adding together some of the preceding terms multiplied by appropriate constants. If we let $f_{(x)}$ represent the coefficient of T^x in the expansion of the generating function (7) and, for brevity, write in (8) $V_x = l_x b_x$, then our population series obeys the rule:

$$f_{(x)} = V_\alpha f_{(x-\alpha)} + V_{\alpha+1} f_{(x-\alpha-1)} + \cdots + V_\omega f_{(x-\omega)}, \qquad (9)$$

which may be written in the alternative form,

$$f_{(x+\omega)} - V_\alpha f_{(x+\omega-\alpha)} - V_{\alpha+1} f_{(x+\omega-\alpha-1)} - \cdots - V_\omega f_{(x)}, = 0. \qquad (10)$$

Thus for our "cliff swallow" example, where we had $G = 2T^1 + 2T^2$ we have

$$f_{(x)} = 2f_{(x-1)} + 2f_{(-2)} \text{ or, } f_{(x+2)} - 2f_{(x+1)} - 2f_{(x)} = 0.$$

Formula (10) represents the simplest and best understood type of difference equation, a homogeneous linear difference equation with constant coefficients. It is outside the scope of the present paper to discuss the theory of such equations, which has been given, for example, by Jordan (1950). By the nature of our problem as summarized in formula (9), all of our V_x values are either equal to zero or are positive real numbers and all of the signs of the coefficients in (9) are positive: features which considerably simplify generalizations. By virtue of these facts it can be shown that there is always a "characteristic" algebraic equation corresponding to (10). This is obtained by writing ρ^x for $f_{(x)}$ and dividing through by the ρ value of smallest index. This gives

$$\rho^\omega - V_\alpha \rho^{\omega-\alpha} - V_{\alpha+1}\rho^{\omega-\alpha-1} \cdots - V_\omega = 0 \qquad (11)$$

an algebraic equation which has the roots ρ_1, ρ_2, etc.

The general solution of the corresponding difference equation (10) is

$$f_{(x)} = C_1\rho_1^x + C_2\rho_2^x + \cdots + C_n\rho_n^x \qquad (12)$$

where the C's are constants to be determined by the initial conditions of the problem. Formula (12) is precisely equivalent to Thompson's method and is a general expression for the number of births or the population size in any future time interval.

As an example we may consider the case where $G = 2T^1 + 2T^2$. The difference equation, as already noted, is $f_{(x+2)} - 2f_{(x+1)} - 2f_{(x)} = 0$ and the characteristic algebraic equation is $\rho^2 - 2\rho - 2 = 0$ which is a quadratic equation with the roots $\rho_1 = 1 + \sqrt{3}$, and $\rho_2 = 1 - \sqrt{3}$. Hence the general solution is $f_{(x)} = C_1(1 + \sqrt{3})^x + C_2(1 - \sqrt{3})^x$. To determine the constants C_1 and C_2 we look at the beginning a of the seriesnd note that we have $f_{(0)} = 1$ and $f_{(1)} = 2$. Substituting these values in the general solution we obtain $C_1 = \dfrac{\sqrt{3}+1}{2\sqrt{3}}$ and $C_2 = \dfrac{\sqrt{3}-1}{2\sqrt{3}}$. Therefore, the general expression for the number of births in time interval T^x is

$$f_{(x)} = \frac{\sqrt{3}+1}{2\sqrt{3}}(1+\sqrt{3})^x + \frac{\sqrt{3}-1}{2\sqrt{3}}(1-\sqrt{3})^x$$

which can be simplified to $f_{(x)} = \dfrac{\rho_1^{x+1} - \rho_2^{x+1}}{\sqrt{3}} = \rho_1^x + \rho_1^{x-1}\rho_2 + \cdots + \rho_2^x$.

In order to have the difference equation (12) correspond to the equation of exponential growth (1^r), the ratio between populations in successive time intervals must assume a constant value giving

$$\frac{f_{(x+1)}}{f_{(x)}} = e^r. \qquad (13)$$

By the nature of our problem, as already noted, the potential population growth is always positive, so

that any limit approached by the ratio $\frac{f_{(x+1)}}{f_{(x)}}$ must be a positive real number.

It is beyond the scope of the present paper to discuss the conditions, for difference equations in general, under which this ratio does approach as a limit the largest real root of the characteristic algebraic equation. (See, for example, Milne-Thompson, 1933, chap. 17). Dunkel (1925) refers to the homogeneous equation with real constant coefficients corresponding to our formulas (10) and (11). The algebraic equation (11) has a single positive root which cannot be exceeded in absolute value by any other root, real or complex. Using (12) to express the ratio between successive terms, we have

$$\frac{f_{(x+1)}}{f_{(x)}} = \frac{C_1\rho_1^{x+1} + C_2\rho_2^{x+1} + \cdots + C_n\rho_n^{x+1}}{C_1\rho_1^{x} + C_2\rho_2^{x} + \cdots + C_n\rho_n^{x}}. \quad (14)$$

If we let ρ_1 represent the root of (11) of greatest absolute value and divide both numerator and denominator of (14) by $C_1\rho_1^x$ we obtain

$$\frac{f_{(x+1)}}{f_{(x)}} = \rho_1\left[\frac{1 + \frac{C_2}{C_1}\left(\frac{\rho_2}{\rho_1}\right)^{x+1} + \frac{C_3}{C_1}\left(\frac{\rho_3}{\rho_1}\right)^{x+1} + \cdots + \frac{C_n}{C_1}\left(\frac{\rho_n}{\rho_1}\right)^{x+1}}{1 + \frac{C_2}{C_1}\left(\frac{\rho_2}{\rho_1}\right)^{x} + \frac{C_3}{C_1}\left(\frac{\rho_3}{\rho_1}\right)^{x} + \cdots + \frac{C_n}{C_1}\left(\frac{\rho_n}{\rho_1}\right)^{x}}\right]. \quad (15)$$

The expressions in parentheses are all less than unity, on the assumption that ρ_1 is the largest root, and the entire expression in brackets approaches unity as x increases. Consequently we have, for x large

$$\frac{f_{(x+1)}}{f_{(x)}} \sim \rho_1 \sim e^r. \quad (16)$$

This then explains the shape of the potential birth and population series as illustrated in Fig. 1. In the very early stages population growth is irregular, because the expressions in (12) and (15) involving the negative and complex roots of (11) are still large enough to exert an appreciable influence. As x increases, the influence of these other roots becomes negligible and the population grows exponentially, conforming to (16). In considering potential population growth we are concerned with the ultimate influence of life-history features, and the equation of geometric progression or compound interest does actually represent the form of potential population growth. We are interested only in the single positive root of (11) for the purpose of determining the constant r, and this can readily be computed with any desired degree of precision by elementary algebraic methods.

Having established the relationship of formula (13) or (16), it is easy to reconcile Thompson's discontinuous approach to population growth with Lotka's continuous approach, as exemplified by formulas (3), (4), and (5).

Employing formula (9) we may write the ratio between populations in successive time intervals as

$$\frac{f_{(x+1)}}{f_{(x)}} = V_\alpha\frac{f_{(x-\alpha+1)}}{f_{(x)}} + V_{\alpha+1}\frac{f_{(x-\alpha)}}{f_{(x)}} + \cdots + V_\omega\frac{f_{(x-\omega+1)}}{f_{(x)}}.$$

Substituting the relationship given by (13), this becomes

$$e^r = V_\alpha e^{-r(\alpha-1)} + V_{\alpha+1}e^{-r\alpha} + \cdots + V_\omega e^{-r(\omega-1)}, \text{ or}$$

$$1 = V_\alpha e^{-r\alpha} + V_{\alpha+1}e^{-r(\alpha+1)} + \cdots + V_\omega e^{-r\omega}.$$

Replacing V_x by its equivalent, $l_x b_x$, this is

$$1 = \sum_{x=\alpha}^{\omega} e^{-rx} l_x b_x. \quad (17)$$

Formula (17) is the precise equivalent in terms of finite time intervals of Lotka's equation (3) for infinitesimal time intervals. In Lotka's equation, as in (17), the limits of integration in practice are α and ω since b_x is zero outside of these limits. Formula (17) was in fact employed by Birch (1948) as an approximation to (3) in his method of determining r for an insect population. The only approximation involved in our derivation of (17) is the excellent one expressed by formula (13); otherwise the formula corresponds to Thompson's exact computational methods. It is hoped that recognition of this fact will make some of the approaches of population mathematics appear more realistic from the biological point of view.

Formulas (4) and (5), originally due to Lotka, are also immediately derivable from the relationship (13). In any time interval, T_x, we may say that the population members aged 0 to 1 are

simply the births in that interval, say B_x. The population members aged 1 to 2 are the survivors of the births in the previous interval, that is $l_1 B_{x-1}$, or employing (13), $l_1 B_x e^{-r}$. Quite generally, the population members aged between x and $x + 1$ are the survivors from the birth x intervals previous, or $l_x B_x e^{-rx}$. If λ is the extreme length of life for any population members ($l_{\lambda+1} = 0$) we have for the total population

$$P_x = B_x(1 + l_1 e^{-r} + l_2 e^{-2r} + \cdots + l_\lambda e^{-\lambda r}) = B_x \sum_{x=0}^{\lambda} e^{-rx} l_x.$$

The birth rate per individual, β, is B_x/P_x, therefore,

$$1/\beta = \sum_{0}^{\lambda} e^{-rx} l_x \tag{18}$$

which is the equivalent in finite time intervals of Lotka's equation (4). Also the proportion, c_x, of the population in the age range x to $x + 1$ is $\frac{l_x B_x e^{-rx}}{P_x}$ which is simply,

$$c_x = \beta e^{-rx} l_x. \tag{5}$$

COMPUTATIONAL METHODS

In the following sections we will examine some of the population effects which are the consequences of particular life history patterns. Probably the most significant comparisons are those involving the effects of life-history features on the intrinsic rate of natural increase, r. Of course, any change in r is accompanied by other effects, such as those on the age-structure and on the population birth-rate. However, the intrinsic rate of increase is a parameter of fundamental ecological importance. If a species is exposed to conditions which would favor the ability to outbreed competitors or where exceptional hazards limit the probability that an individual will become established, we might expect to find life-history adjustments tending to increase the value of r. Conversely, if a species has evolved life-history features of a type tending to hold down the intrinsic rate of increase, a fertile field of inquiry may be opened regarding the selective factors to which such a species is subject.

It is probably fairly obvious to anyone that in general a species might increase its biotic potential by increasing the number of offspring produced at a time (litter size), by reducing mortality at least until the end of active reproductive life, by reproducing oftener, by beginning reproduction at an earlier age, or by minimizing any wastage of environmental resources on sterile members of the population. Any biologist will at once recognize, however, that a great deal of evolution (an extreme case is the evolution of sterility in the social insects) has proceeded in precisely the wrong direction to increase biotic potential by some of these devices. Presumably, this can only mean that the optimum biotic potential is not always, or even commonly, the maximum that could conceivably be achieved by selecting for this ability alone. Comparative life-history studies appear to the writer to be fully as meaningful in evolutionary terms as are studies of comparative morphology or comparative physiology.

Although a great many empirical data on life histories have been accumulated, attempts to interpret these data comparatively have lagged far behind the corresponding efforts in morphology and physiology. The methods exhibited in the preceding parts of the present paper are adaptable for the quantitative interpretation of life history features and, while the number of conceivable life-history patterns is infinite, we propose to examine some of the cases which appear to possess particular ecological interest.

The life-history features with which we are concerned are the age at which reproduction begins (α), the litter size and frequency of reproduction (both summarized by a knowledge of the function b_x, which can also be computed so as to take account of the sex ratio), the maximum age at which reproduction occurs (ω), survivorship (l_x), and maximum longevity (λ). Corresponding to any given set of values for these quantities there is a definite value for the intrinsic rate of natural increase (r) and a definite stable age distribution of the population (c_x). In general, these population features will be altered by any alteration of the life-history features and we wish to examine some of these possible changes quantitatively.

The most efficient way of making the desired computations will vary from problem to problem. Thompson's method (formulas (7) and (8)), could be used to obtain exact population values arising from any life history, but the computations would in many cases be exceedingly laborious and would actually yield no more information about the ultimate course of population growth than would be obtained by solving (11) for the positive root.

In either case it will usually be most efficient to measure time in terms of the shortest interval between the pertinent life-history events with which we are concerned.

Except in very special cases, it is necessary to use iterative methods for obtaining the value of r corresponding to particular life-history patterns. In most cases the solutions are quite rapidly obtained by employing a calculating machine and detailed tables of natural logarithms (e.g., Lowan, 1941) or of the exponential function (e.g., Newman, 1883). In the majority of the cases considered by the writer, the most efficient procedure has been to rewrite formula (17) in the form:

$$e^{ra} = V_\alpha + V_{\alpha+1}e^{-r} + V_{\alpha+2}e^{-2r} + \cdots + V_\omega e^{-r(\omega-\alpha)} \qquad (19)$$

and then to obtain the sum of the series on the right-hand side of (19) for different patterns of variation in the function $l_x b_x = V_x$. This method corresponds exactly to the discontinuous approach, granting only that potential population growth is a geometric progression, and it leads to relatively simple equations in a number of the cases of greatest ecological interest.

A more general approach from the standpoint of formal mathematics can be obtained by rewriting (3) in the form of a Stieltjes integral (Widder, 1940). We may define a maternity function $M(x)$ representing the average number of offspring which an individual will have produced by the time it has attained any age x, and such that its derivative with respect to time is $\left(V_x \frac{d}{dx}M(x) = V_x\right)$. We then have

$$\int_0^\omega e^{-rx}\,dM(x) = 1 \qquad (20)$$

which can represent cases where $V_{(x)}$ is either continuous or discontinuous because the integral vanishes for values where V_x is discontinuous. When V_x can be expressed as a function of time (x), formula (20) is identical with (3) and the use of the Laplace transformation, a procedure of considerable importance in engineering and physical mathematics, makes it possible to avoid the numerical integration and express V_x as a function of r. If V_x is considered as a series of single impulses regularly spaced from α to ω, equation (20) assumes the form (17). Laplace transformations for a number of functions are tabulated by Churchill (1944) and Widder (1947) and, no doubt, there are cases where this procedure would lead to simpler iterative solutions than those obtained from equation (19). For the cases considered in the present paper, however, the solution of equation (19) generally leads to somewhat simpler results.

In dealing with any particular life-history pattern the computational method of choice may depend upon the types of features to be investigated. The pure numbers α, ω, and λ typically offer no particular computational problems, as they are assigned different values, but this is not always the case with the functions b_x and l_x.

In the cases considered by the writer the intervals between successive periods of reproduction have been considered to be equal. There is no particular difficulty in altering this assumption so as to consider cases where the frequency of reproduction varies with age, but regular spacing seems to be so much more usual in nature as well as representing a limiting case that it seems to merit first consideration. Litter size often does vary with the age of the parent organism, and this fact may introduce complexities into the behavior of the function V_x. In this case also, it appears that the ecologically most interesting cases are those in which the average litter size is a constant. Furthermore, as will become apparent in later sections, the first few litters produced by an organism so dominate its contribution to future population growth that later changes in litter size would have only very minor population consequences. In dealing with empirical data on human populations attempts have been made to express analytically the changes in b_x with age [cf. "Tait's law" that fertility declines in a linear manner (Yule, 1906; Lotka, 1927)] but for the present we shall consider that b_x assumes only the values zero and some constant, b.

The shape of the survivorship (l_x) curve is more difficult to deal with in a realistic manner. Pearl and Miner (1935) originated the classification of survivorship curves which is most employed for ecological purposes (cf. Deevey, 1947; Allee et al., 1949). The "physiological" survivorship curve is the limiting type in which each individual lives to some limit characteristic of the species and the age at death (λ) is regarded as a constant. In this case $l_x = 1$ when $x < \lambda$ and $l_x = 0$ when $x > \lambda$. This is the simplest case for computations, and actual cases are known which approach this type. Furthermore, there are other types of survivorship curves of ecological interest which may be treated

in the same manner. In what Deevey (1947) calls Type III there is an extremely heavy early mortality with the few survivors tending to live out a "normal life span." For the computation of r we are only concerned (cf. formula 19) with survivorship during the reproductive span of life, and it appears likely that "Type III" curves can be treated as constant throughout this age range without serious error. Another interesting type of survivorship curve which appears to be consistent with empirical data at least on some wild populations (cf. Jackson, 1939; Deevey, 1947; Ricker, 1948) is that in which a constant proportion of the population dies in each interval of age. This, of course, implies that life expectancy is independent of age, an assumption which cannot in general be considered realistic but which might apply to catastrophic causes of mortality. When this type of l_x curve applies, the V_x values will be in geometric progression and the right side of formula (19) can be summed as easily as in the case where V_x is constant. This case is, therefore, easily dealt with.

The type of survivorship curve usually observed in actual cases is a reverse sigmoid curve, interpreted by Deevey as intermediate between the "physiological" type and the geometric progression. This can be interpreted in various ways as a "wearing-out" curve. Gompertz (1825) attempted to find an analytical form on the assumption that the ability of individuals to "resist destruction" decreases as a geometric progression with age. Elston (1923) has reviewed formulas proposed to represent human mortality; none of these has proved generally applicable, despite great complexity in some cases. Another approach is to assume that some sort of a "vital momentum" (Pearl, 1946) or ability to survive is distributed among the members of the population in the form of a bell-shaped or "normal" frequency distribution. This point of view is a familiar and controversial one in the recent literature on bio-assay problems (Finney, 1947, 1949; Berkson, 1944, 1951) and, at least to the extent that a bell-shaped curve can represent the empirical distribution of ages at death, a probit function or a logit function (Berkson, 1944) can be used to represent l_x.

In the present paper we are concerned primarily with the limiting cases or the *potential* meaning of life-history phenomena. Consequently the writer has chosen to deal with survivorship curves of the physiological type and thus to investigate the ultimate effects of life-history phenomena for a species which is able to reduce mortality during the reproductive part of the life span to a negligible value. Our general conclusions will not be seriously altered even by rather startling drastic alterations of this assumption, and, in any case, our results will indicate the maximum gain which a species might realize by altering its life-history features.

Perhaps the most fundamental type of life-history pattern to be investigated in terms of population consequences is that in which the individuals are assumed to produce their first offspring at the age of α "years" with the mean litter size being a constant, b. A second litter is produced at age $\alpha + 1$ and an additional litter in each subsequent interval of age out to, and including, age ω. The total number of litters produced per individual is then $n = \omega - \alpha + 1$.

We then have, from (19),

$$e^{r\alpha} = b(1 + e^{-r} + e^{-2r} + \cdots + e^{-r(\omega-\alpha)}).$$

The expression in parentheses is a geometric progression the sum of which is $\frac{1 - e^{-rn}}{1 - e^{-r}}$. Consequently, the general implicit equation for r under these conditions may be written

$$1 = e^{-r} + be^{-r\alpha} - be^{-r(\omega+\alpha)} \qquad (21)$$

which may be solved by trial and error by employing a table of the descending exponential function.

Alternative formulas corresponding to (21) may be obtained by the use of the Laplace transformation. In the case where reproduction is considered to occur as a series of regularly spaced impulses, this approach leads to formula (21). Another approach is to consider that $V_x = 0$ when $x < \alpha$, $V_x = b$ when $\alpha \leqq x \leqq \omega$, and $V_x = 0$ when $x > \omega$. The Laplace transformation of a step-function is then employed, leading to the formula

$$\frac{be^{-r\alpha}}{r} - \frac{be^{-r(\omega+1)}}{r} = 1. \qquad (22)$$

Formula (22) and formula (21) would be identical under the condition that $r + e^{-r} = 1$, which is approximately true when r is small. If one desires more nearly to reconcile the continuous and discontinuous approaches in this case, he may note that in formula (21) he is finding the area under a "staircase-shaped" curve with the first vertical step located at $x = \alpha$, whereas in formula (22) he

is finding the area under a straight line paralleling the slope of the staircase. It is apparent that the two areas will be more nearly identical if the straight line is started about one-half unit of time earlier. If we substitute in (22) $\alpha - \frac{1}{2}$ for α and $\omega - \frac{1}{2}$ for ω we obtain a formula which gives results for practical purposes identical with those obtained from (21). The formulas are about equally laborious to solve, and the writer has employed (21) for the following computations because of its more obvious relationship to the exact computational methods.

POSSIBLE VALUES OF REPEATED REPRODUCTION (ITEROPARITY)

One of the most significant of the possible classifications of life histories rests on the distinction between species which reproduce only once in a lifetime and those in which the individuals reproduce repeatedly. This being the case, it is very surprising that there seem to be no general terms to describe these two conditions. The writer proposes to employ the term semelparity to describe the condition of multiplying only once in a lifetime, whether such multiplication involves fission, sporulation, or the production of eggs, seeds, or live young. Thus nearly all annual plants and animals, as well as many protozoa, bacteria, insects, and some perennial forms such as century plants and the Pacific salmon, are semelparous species. The contrasting condition will be referred to as iteroparity. Iteroparous species include some, such as small rodents, where only two or three litters of young are produced in a lifetime, and also various trees and tapeworms where a single individual may produce thousands of litters. The distinction between annual and perennial plants is doubtless the most familiar dichotomy separating semelparous and iteroparous species, but general consideration of the possible importance of these two distinct reproductive habits illustrates some points of ecological and evolutionary interest. For purposes of illustration we shall first consider cases where the time interval between reproductive efforts is fixed at one year.

Many plants and animals are annuals. This is true, for example, of many of the higher fungi and seed plants, of insects, and even of a few vertebrates. One feels intuitively that natural selection should favor the perennial reproductive habit because an individual producing seeds or young annually over a period of several years obviously has the potential ability to produce many more offspring then is the case when reproduction occurs but once. It is, therefore, a matter of some interest to examine the effect of iteroparity on the intrinsic rate of natural increase in order to see if we can find an explanation for the fact that repeated reproduction is not more general.

Let us consider first the case of an annual plant (or animal) maturing in a single summer and dying in the fall at the time of reproduction. We have seen earlier (formula 16, seq.) that if b is the number of offspring produced by such an annual the intrinsic rate of increase would be the natural logarithm of b. We wish to determine by how much this would be increased if the individual were to survive for some additional years, producing b offspring each year. Obviously, an annual species with a litter size of one (or an average of one female per litter in sexual species) would merely be replacing current population and no growth would be possible ($\ln 1 = 0$); therefore, when the litter size is one the species must necessarily be iteroparous.

The most extreme case of iteroparity, and the one exhibiting the absolute maximum gain which could be achieved by this means, would be the biologically unattainable case of a species with each individual producing b offspring each year for all eternity and with no mortality. In this case we have $\alpha = 1$ "year" and, since ω is indefinitely large, the final term $be^{-r(\omega+1)}$ in equation (21) becomes zero. Thus we have

$$r = \ln(b + 1) \tag{23}$$

which is to be contrasted with $r = \ln(b)$ for the case of an annual. *For an annual species, the absolute gain in intrinsic population growth which could be achieved by changing to the perennial reproductive habit would be exactly equivalent to adding one individual to the average litter size.* Of course, this gain might be appreciable for a species unable to increase its average litter size. The extreme gain from iteroparity for a species with a litter size of two would be ($\ln 3/\ln 2$) or an increase of about 58 per cent, for a species with a litter size of four the increase would be about 16 per cent, but for one producing 30 offspring in a single reproductive period the extreme gain would amount to less than one per cent. It seems probable that a change in life history which would add one to the litter size would be more likely to occur than a change permitting repeated reproduction, which in many

cases would necessitate adjustments to survive several seasons of dormancy. It appears that for the usual annual plants and insects with their relatively high fecundity any selective pressure for perennial reproduction as a means of increasing biotic potential must be negligible.

The above conclusion, which appears surprising when first encountered, arouses curiosity as to why iteroparity exists at all. Perhaps some species are physiologically unable to increase their fecundity. This must, however, be unusual and we are led to investigate whether the situation would be different for a species with a prolonged period of development preceding reproduction. One thinks immediately of the giant Sequoias which require a century to mature and begin reproduction but which, once started, produce large numbers of seeds biennially for centuries.

In order to investigate this question we may again compare the intrinsic rate of increase for a single reproduction with that corresponding to an infinite number of reproductions. This procedure will, of course, tend to overestimate the possible gain from iteroparity although it will set an upper limit, and the first few reproductive periods so dominate the situation that even for very modest litter sizes there is a negligible difference between the results of a very limited number of reproductive periods and an infinite number.

For α not necessarily equal to one, formula (21) gives

$$b = e^{r\alpha} - e^{r(\alpha-1)}, \tag{24}$$

an implicit equation for r which must be solved by iterative means.

Fig. 2 was constructed from formula (24) to show the relationship between the age at which reproduction begins (α) and the litter size (b) in terms of the possible gain in intrinsic rate of increase which could be achieved by iteroparity. The ordinates represent the proportionate increase in the value of r which could be achieved by changing from a single reproductive effort at age α to an infinite number at ages α, $\alpha + 1$, $\alpha + 2$, etc. The curves all slope upward, indicating that species with long pre-reproductive periods could gain more

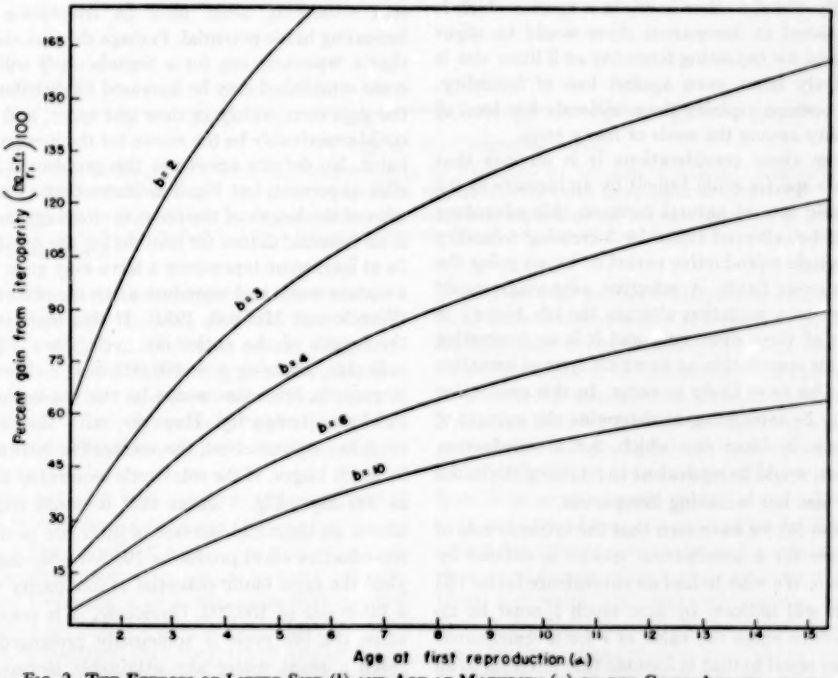

FIG. 2. THE EFFECTS OF LITTER SIZE (b) AND AGE AT MATURITY (α) ON THE GAINS ATTAINABLE BY REPEATED REPRODUCTION

The litter size, b, is the number of female offspring per litter in the case of sexual species.

from iteroparity than forms which mature more rapidly. The tendency of the curves to flatten out with large values of α, however, indicates that the advantages of repeated reproduction increase somewhat less rapidly as the pre-reproductive period is prolonged.

The relationship of iteroparity to litter size is clearly illustrated by Fig. 2. When the litter size is small, as shown by the curve for $b = 2$ (which would correspond to a litter of four individuals when the sex ratio is 1:1), iteroparity can yield important gains in biotic potential, and the possible gains are greater the longer maturity is delayed. The possible advantages diminish quite rapidly as litter size is increased, although it is clear that iteroparity as contrasted with a single reproductive effort would always add something to biotic potential.

Fig. 2 suggests that for semelparous species with large litters there would be very slight selective pressure in favor of adopting the iteroparous habit, and that for iteroparous species with large litters there would be little selection against loss of the iteroparous habit, especially in forms which mature rapidly. On the other hand, in a species which is established as iteroparous there would be slight selection for increasing fecundity or if litter size is relatively large, even against loss of fecundity. This perhaps explains the notoriously low level of viability among the seeds of many trees.

From these considerations it is obvious that when a species could benefit by an increase in the intrinsic rate of natural increase, this advantage might be achieved either by increasing fecundity in a single reproductive period or by adopting the iteroparous habit. A selective advantage would accrue to a mutation altering the life history in either of these directions, and it is an interesting field for speculation as to which type of mutation might be most likely to occur. In this connection it may be interesting to determine the amount of increase in litter size which, for a semelparous species, would be equivalent to retaining the initial litter size but becoming iteroparous.

From (6) we have seen that the intrinsic rate of increase for a semelparous species is defined by $e^{r\alpha} = b$. We wish to find an equivalence factor (E) which will indicate by how much b must be increased to make the value of r for a semelparous species equal to that in formula (21) referring to an iteroparous species. By neglecting the last term in (21) so as to consider the most extreme case of iteroparity and substituting $Eb = e^{r\alpha}$, we obtain

$$E = \frac{1}{1 - e^{-r}} = \frac{e^{r\alpha}}{b} \tag{25}$$

where the value of r must be obtained by solving equation (21). When E is plotted against α for various values of b, as shown in Fig. 3, the resulting curves are essentially straight lines.

Fig. 3 illustrates some interesting points bearing on the life histories of organisms, such as tapeworms and many trees, which are iteroparous in addition to producing large litters. From the arrangement of Fig. 2 one might suspect that the iteroparous habit would provide very little advantage to a species that could produce a thousand or so offspring in a single litter, but Fig. 3 indicates that the selective value of iteroparity may be greatly increased when the pre-reproductive part of the life span is prolonged.

A mature tapeworm may produce daily a number of eggs on the order of 100,000 and may continue this for years (Allee et al., 1949, p. 272; Hyman, 1951). With so large a litter size one wonders if iteroparity in this case may not represent something other than an adaptation for increasing biotic potential. Perhaps the probability that a tapeworm egg (or a *Sequoia* seed) will become established may be increased by distributing the eggs more widely in time and space, and this could conceivably be the reason for the iteroparous habit. No definite answer to this problem is possible at present, but Fig. 3 indicates that a knowledge of the length of the life cycle from egg to egg is an essential datum for considering the question. In at least some tapeworms a larva may grow into a mature worm and reproduce at an age of 30 days (Wardle and McLeod, 1952). If this represented the length of the entire life cycle, then Fig. 3 indicates, assuming $b = 100{,}000$, that a threefold increase in litter size would be the equivalent of indefinite iteroparity. However, with the larval stage in a separate host, the average life cycle must be much longer. If the total cycle requires as much as 100 days, Fig. 3 shows that it would require almost an eight-fold increase in litter size (a single reproductive effort producing 790,167 offspring) to yield the same biotic potential as iteroparity with a litter size of 100,000. Obviously, it is possible, when the life cycle is sufficiently prolonged, to reach a point where any attainable increase in litter size would be less advantageous for potential population growth than a change to the iteroparous

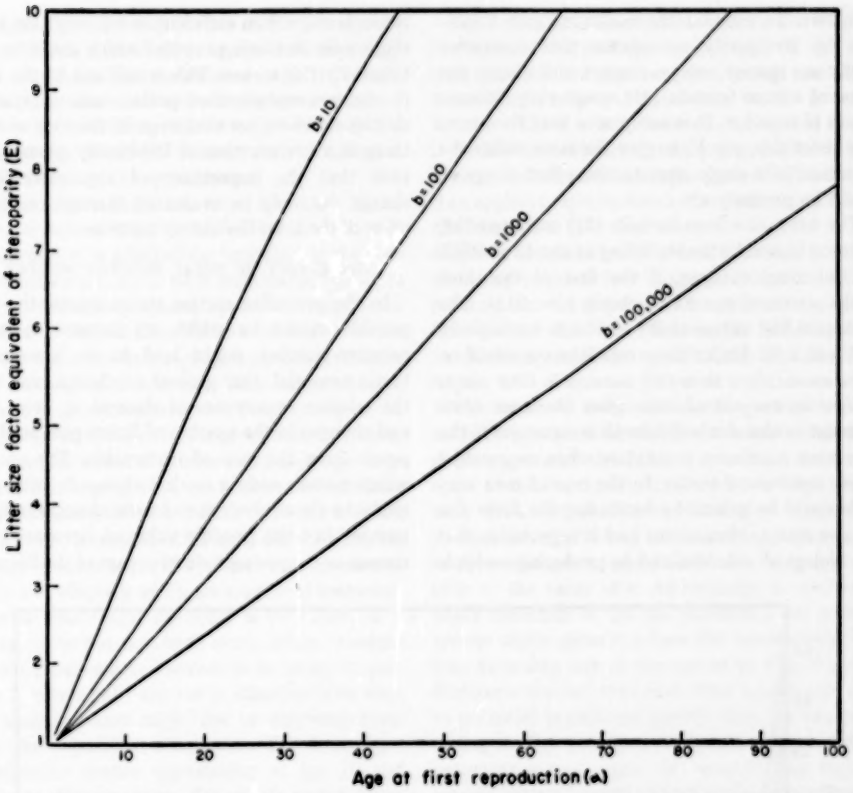

FIG. 3. THE CHANGES IN LITTER SIZE WHICH WOULD BE REQUIRED TO ACHIEVE IN A SINGLE REPRODUCTION THE SAME INTRINSIC RATE OF INCREASE THAT WOULD RESULT FROM INDEFINITE ITEROPARITY

b represents the litter size for an iteroparous species and the ordinate scale (*E*) represents the factor by which *b* would have to be multiplied to attain the same intrinsic rate of increase when each female produces only one litter in her lifetime.

habit. Hence a selective pressure can operate in favor of iteroparity even when the litter size is large. It is clear from Fig. 3, noting the greater slope of the lines representing smaller litter sizes, that in these cases the point will be reached more quickly at which the potential gains from iteroparity outweigh those attainable by increasing the litter size.

Man has a life cycle which is rather unusual in that it combines a long pre-reproductive period with a very small litter size; the very conditions under which iteroparity should be most advantageous. Everyone is, of course, aware that multiple births occur in man but with such a low frequency in the population that they are of negligible importance in population phenomena. It is also rather generally accepted that there is a hereditary basis for the production of multiple births. The question arises as to why increased litter size should not become more common simply as a result of increased contributions to subsequent population resulting from the increase in biotic potential associated with large litters. It should be of interest, therefore, to determine how large a litter would have to be produced in a single reproductive effort to provide an intrinsic rate of increase equal to that resulting from three or more single births.

In the case of man we may rather confidently accept the value $b = 1/2$ to signify that the average number of female offspring produced per human birth, and which will ultimately mature, is one-half. Accepting this value means that a mother must on the average produce two "litters" merely to replace herself (to give $r = 0$), so we shall examine the intrinsic rate of increase only for cases where n, the total number of births, is greater

than two. To examine the maximum gain attainable by iteroparity we assume that successive births are spaced one year apart and obtain the value of r from formula (21), employing different values of n and α. It is easily seen that the necessary litter size, say b', to give the same value of r by means of a single reproductive effort at age α, would be precisely $e^{r\alpha}$.

The value of r from formula (21) corresponding to three annual births beginning at age 12 is .0312. At the other extreme, if the first of the three births occurs at age 30 we obtain $r = .0131$. The corresponding values of $e^{r\alpha} = b'$ are successively 1.41 and 1.48. Under these conditions *it would require essentially a three-fold increase in litter size to achieve in one reproductive effort the same biotic potential as that obtained from three successive births.* The same conclusion is obtained when we consider larger numbers of births. In the case of man very little could be gained by increasing the litter size by any reasonable amount and it is probable that the biological risk involved in producing multiple births is more than sufficient to outweigh the very slight gain in biotic potential which could be obtained by this means. This would not be the case if the pre-reproductive period was drastically shortened, so we see that even in the case of man there is an interaction of life-history phenomena such that the importance of any conceivable change can only be evaluated through consideration of the total life-history pattern.

THE EFFECT OF TOTAL PROGENY NUMBER

In the preceding section we compared the two possible means by which an increase in total progeny number might lead to an increase in biotic potential. Our general conclusion was that the relative importance of changes in litter size and changes in the number of litters produced depends upon the rate of maturation. For species which mature early a modest change in litter size might be the equivalent of drastic changes in litter number but the possible value of iteroparity increases as the pre-reproductive part of the life span

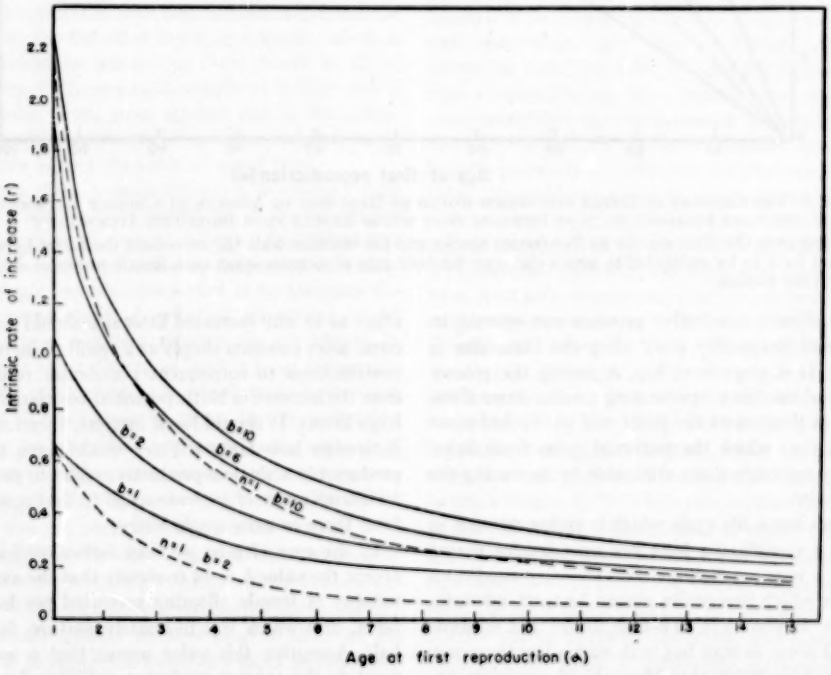

FIG. 4. THE EFFECT OF DELAYED MATURITY ON THE INTRINSIC RATE OF NATURAL INCREASE

The two broken lines represent semelparous species. The solid lines represent indefinitely iteroparous species where each female, after producing her first litter of size b, produces another similar litter in every succeeding time interval.

is lengthened. The importance of discovering the age at which reproduction begins has commonly been overlooked by students of natural history, hence it appears worthwhile to explore the matter further by examining the actual values of the intrinsic rate of natural increase corresponding to specified patterns of reproduction.

Fig. 4 was constructed from formula (21) to show, for several litter sizes, how the intrinsic rate of increase, r, is affected by lengthening the pre-reproductive period, α. Both semelparous ($n = 1$) and indefinitely iteroparous ($n = \infty$) species are illustrated. The striking feature of Fig. 4 is the way in which the lines representing different litter sizes converge as α increases. This occurs whether there is a single reproduction per lifetime or an infinite number, hence it is a general phenomenon. This supplements our earlier conclusions by suggesting that in species where reproductive maturity is delayed there should be relatively slight selection pressure for increased litter size. Here we are referring, of course, to the effective litter size or number of offspring which are capable of maturing. In cases where early mortality is very high, as is known to be the case with many fishes, it might require a tremendous increase in fecundity to produce a very small increase in effective litter size, and such increases might not be very important from the population standpoint. For example, a semelparous species reproducing at age 20 and with an effective litter size of 10 would have, $r = 0.120$. A ten-fold increase in litter size, to $b = 100$, would give $r = 0.231$ or an increase in biotic potential of 92 per cent. Another ten-fold increase to $b = 1000$ would give $r = 0.345$, or a gain of 50 per cent. The diminishing returns attainable by increasing litter size are obvious. For an iteroparous species reproducing first at age 20 and thereafter in each subsequent time interval, the increase in effective litter size from 10 to 100 would give only a 50 per cent increase in biotic potential and a further ten-fold increase in litter size would increase r by only another 35 per cent. In late-maturing species the litter size must be great enough to make it highly probable that *some* of the progeny will mature, but any further increases in fecundity will yield rapidly diminishing returns.

It is also clear from Fig. 4 that for any fixed litter size the biotic potential could be increased by shortening the period of maturation. Any specified amount of decrease in the pre-reproductive period will, however, be most effective for species where this part of the life span is already short.

Fig. 5 illustrates the way in which the two factors of length of the pre-reproductive part of the life span (α) and the number of offspring produced interact to determine the intrinsic rate of natural increase. These values were also computed from formula (21), in this case considering the litter size, b, as a constant with the value one-half. The figure then applies to species which, like man, produce one offspring at a time and where one-half of these offspring are females. Under these conditions it obviously requires two births just to replace the parents, but the population consequences of producing more than two offspring per lifetime vary tremendously with the age at which reproduction begins.

The female of the extinct passenger pigeon presumably produced her first brood consisting of a single egg at the age of one year. From the steep slope of the line representing $\alpha = 1$ in Fig. 5 it is clear that, beyond the minimum of two eggs per average female, several additional eggs produced in successive years would each add very appreciably to the value of r. Accordingly, a relatively slight reduction of the life expectancy for such a species might greatly reduce the biotic potential. The flattening out of the curves in Fig. 5 again illustrates the fact that each litter contributes less to potential population growth than the one preceding it. However, in a case such as that of the passenger pigeon even the seventh and eighth annual "litters" would add appreciable increments to the value of r.

Fig. 5 also shows that as the age at maturity increases the possible gains in biotic potential attainable by producing many offspring rapidly diminish. When $\alpha = 3$, as in the economically important fur-seal, each pup contributes much less to biotic potential than was the case for the eggs of the passenger pigeon. Nevertheless, it is apparent from the figure that if the life expectancy for females should be reduced to seven or eight years (corresponding to the fifth or sixth pup), or less, the species would be in a vulnerable position. The curve is steep in this portion of the graph and relatively slight changes in average longevity could produce disproportionately large population effects.

The lowest curves in Fig. 5 represent ages at maturity falling within the possible range for man. The curves come close together as α increases, so that in this range a change of a year or two in the age at which reproduction begins is less significant than in the case of a species that matures more

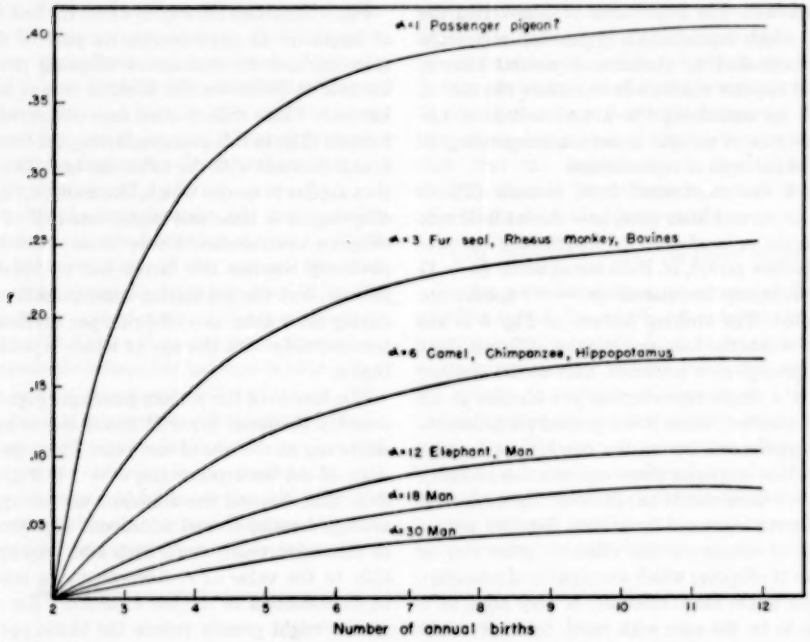

FIG. 5. THE EFFECTS OF PROGENY NUMBER ON THE INTRINSIC RATE OF NATURAL INCREASE WHEN THE LITTER SIZE IS ONE ($b = \frac{1}{2}$)

The ordinate scale shows the intrinsic rate of increase for species which produce an average of one-half female offspring per litter. For any given total progeny number, the intrinsic rate (r) is seen to be greatly affected by the age (α) at which the first offspring is produced.

rapidly. Furthermore, the curves flatten out rapidly so that families which are very large by ordinary standards actually contribute little more to potential population growth or to future population than do families of quite moderate size. As an explicit illustration consider the intrinsic rate of increase which would result if, on the average, human females produced their first offspring at the age of 20 and had a total of five children spaced at one-year intervals. In this case we would have $r = 0.042$. If, on the other hand, we assume that, instead of producing only five children, the females could live forever producing a child each year we would obtain $r = 0.0887$. Under these conditions we conclude that in terms of biotic potential five children are almost one-half (actually 47 per cent) the equivalent of an infinite number. With larger values of α the effect of very large families would be even further reduced. From these considerations the writer feels that human biologists, as well as other natural historians, often overemphasize the importance of total number of progeny while underestimating the significance of the age at which reproduction begins. It is impossible to conclude that one segment of the population is contributing more to future population than is some other segment without examining the total life-history pattern. Age at marriage could, in studying human populations, be a more significant datum than total family size.

The foregoing discussion suggests that a species such as man which is characterized by a long period of maturation and a small litter size can exhibit considerable variability in the details of its life history without greatly affecting the intrinsic rate of natural increase. The population consequences to be anticipated if the average age at which reproduction begins were to be altered by a few years or if the average number of progeny per female were slightly altered are much less striking than is the case for many other species. This implies that the intrinsic rate of increase should be relatively constant over the range of possible variations in the life-history features for man.

Such a conclusion would seem to be of both practical and theoretical interest and to merit closer examination.

The intrinsic rate of increase for man would be the rate of compound interest at which a human population, unrestrained by environmental resistance, would grow. We have already noted that Franklin (1751) estimated that a human population could double in 20 years and that this would correspond to $r = .035$. Malthus (1798) estimated that an unrestrained human population such as that of the United States at that time could double in 25 years. Malthus' estimate corresponds to $r = .0277$ which is remarkably close to the value of $r = .0287$ obtained by Lotka (1927) using much more refined methods for estimating the rate of increase prevailing in 1790 in the United States. Pearl and Reed (1920) fitted a logistic curve to the population figures for the United States, and their equation gives the value $r = .03134$. Additional examples of estimates based on empirical data could be given, but these are sufficient to suggest that the value of the intrinsic rate of increase for man is not far from 0.03.

Fig. 6 was constructed from formula (21) in order to examine the question whether or not the life-history features of man would actually lead us to anticipate the approximate value, $r = 0.03$. Fig. 6 suggests rather definitely that the value $r = 0.02$ is too low, since it falls well below the obvious reproductive capabilities of humans. If females, on the average, had their first child at the age of 12 years (which is possible, cf. Pearl, 1930, p. 223) it would require an average of 2.6 surviving annual births per female to correspond to the rate $r = .02$. This curve is quite flat, so that if the first birth was delayed until the age of 20 years, which seems to be roughly the beginning of the semi-decade of maximum human fertility (Pearl, 1939), three annual births would still be adequate to give $r = .02$. Even if the first birth is delayed until the age of 28 years, this intrinsic rate of increase calls

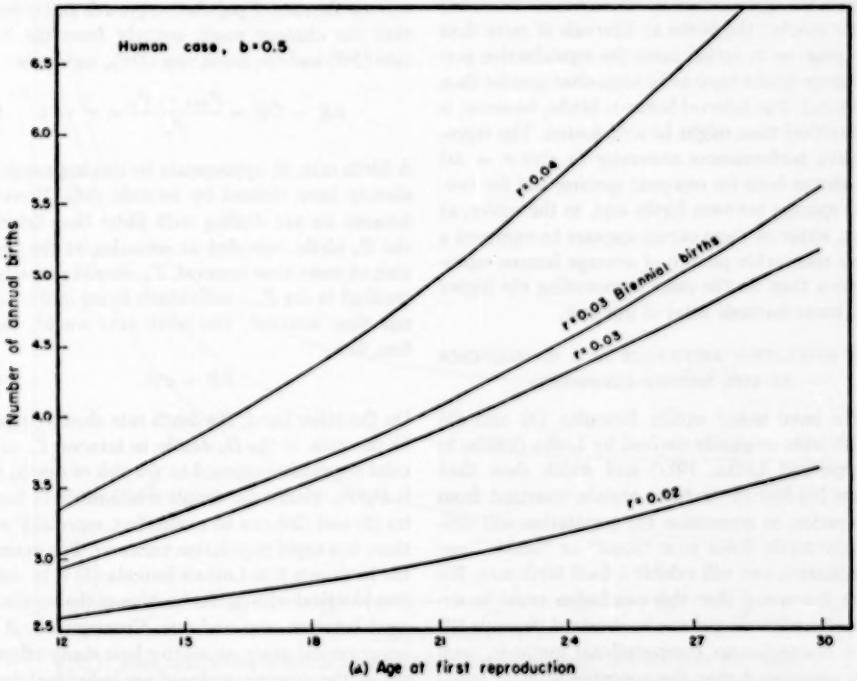

FIG. 6. AVERAGE REPRODUCTIVE PERFORMANCES REQUIRED TO GIVE SPECIFIED VALUES OF r, THE INTRINSIC RATE OF NATURAL INCREASE, IN HUMAN POPULATIONS

Assuming the average number of female offspring per human birth to be one-half ($b = 0.5$), this graph shows the extent to which total progeny number would have to be altered to maintain a specified intrinsic rate of increase while shifting the age at which reproduction begins. The figure also makes it possible to estimate the intrinsic rate of increase for a population when the average reproductive performance per female is known.

for an average progeny number of only 3.5. Clearly, man can easily exceed this average level of performance. On the other hand, the value $r = .04$ seems to require reproductive performance which would be astonishingly high as an average condition. If the first birth occurred when the mother was aged 13 years, an average of 3.5 children per female would suffice to give $r = .04$. However, the curve turns upward and if the first birth was delayed until the age of 20 it would require an average of 4.8 children to obtain this value. A delay of one more year, to the age of 21 for the first child, would increase the necessary mean progeny number to 5.0, while six children would be necessary if the first birth came when the mother was 25 years old. This intrinsic rate of increase then seems to call for exceptional rather than average reproductive performance, and the writer believes that Fig. 6 would lead us to expect that the intrinsic rate of increase for man lies between the limits .02 and .04 and might be estimated at about .03. Of course, the figure makes no allowance for mortality or for spacing the births at intervals of more than one year, so in actual cases the reproductive performance would have to be somewhat greater than indicated. The interval between births, however, is less critical than might be anticipated. The reproductive performances necessary to give $r = .03$ are shown both for one-year spacing and for two-year spacing between births and, to the writer, at least, either of these curves appears to represent a more reasonable picture of average human reproduction than do the cases representing the higher and lower intrinsic rates of increase.

THE POPULATION BIRTH-RATE AS A CONSEQUENCE OF LIFE-HISTORY PHENOMENA

We have noted earlier formulas (4) and (5) which were originally derived by Lotka (1907a, b; Sharpe and Lotka, 1911) and which show that when life-history features remain constant from generation to generation the population will ultimately settle down to a "fixed" or "stable" age distribution and will exhibit a fixed birth rate. We have also noted that this conclusion could be expected intuitively and can be obtained (formula 18) from discontinuous computational methods, once it is established that the potential form of population growth is a geometric progression. These potential consequences appear to provide the best justification for studying the life histories of various species, yet when such studies are conducted it is common practice not to attempt any interpretation in terms of population phenomena.

It is evident from formulas (3), (4), and (5) that the birth rate and the stable age distribution are tied together with the intrinsic rate of increase and that any extensive discussion of the way in which changes in life-history features would affect these population features might repeat many of the points already covered. Consequently, we shall here note very briefly the relationships between life-history features and the resultant phenomena of birth rates and age structure.

If we consider a "closed" population, which changes in size only through the processes of birth and death, it is apparent that the intrinsic rate of increase, r, in formula (1), $\frac{dP}{dx} = rP$, must represent the difference between the instantaneous birth rate and the instantaneous death rate. In practice, however, we are more interested in a finite rate of population change. If we employ formula (1′) to express the rate of population growth and consider that the changes result entirely from the birth rate (BR) and the death rate (DR), we obtain:

$$BR - DR = \frac{P_{x+1} - P_x}{P_x} = e^r - 1. \quad (26)$$

A birth rate, β, appropriate to this approach has already been defined by formula (18). However, because we are dealing with finite time intervals the B_x births regarded as occurring at the beginning of some time interval, T_x, should properly be credited to the P_{x-1} individuals living in the previous time interval. The birth rate would, therefore, be:

$$BR = e^r\beta. \quad (27)$$

On the other hand, the death rate should properly be the ratio of the D_x deaths in interval T_x to the total population exposed to the risk of death; that is D_x/P_x. Hence the simple relationship of formulas (5) and (26) can be misleading, especially when there is a rapid population turnover. For example, the birth rate β in Lotka's formula (5) is by definition identical with c_0, the fraction of the population aged between zero and one. Consequently β can never exceed unity no matter how many offspring are on the average produced per individual during a time interval.

In practical population problems the crude birth rate is often observed and employed as a criterion of the state of the population. This

practice can be misleading, especially in comparing species which differ widely in their life-history features. It would be redundant to undertake a detailed analysis of the way in which life-history phenomena affect the crude birth rate because, as is evident from formulas (5), (26), and (27), any change which affects the value of r also affects the population birth-rate. However, the birth rate is subject to additional influences and these may be briefly examined.

The methods used in computing the value of r (formulas 17, 21, and 22) have involved survivorship only out to the age ω at which reproduction ceases. In species having a post-reproductive part of the life span, the crude birth rate corresponding to a given value of r will be reduced simply because post-reproductive individuals accumulate and are counted as part of the population on which the computations are based. It is clear, therefore, that any increase in longevity (λ) which is not accompanied by an increase in ω will tend to lower the observed birth rate; conversely, the birth rate must affect the age structure of the population.

If the maximum longevity for a species is λ, a continued birth rate of $1/\lambda$ would just suffice to leave a replacement behind at the time each individual dies. Hence $1/\lambda$ represents an absolute minimum for a steady birth rate which is capable of maintaining the population. For example, if it were possible to keep every human female alive for 100 years a birth rate as low as 0.01 or 10 births per thousand population per annum (assuming ½ of the offspring to be females), could theoretically suffice for population maintenance. However, for human females the value of ω is not much beyond 40 years; in general, if a female has not produced a replacement by the age of 40 she is not going to do so. The latter consideration might lead one to

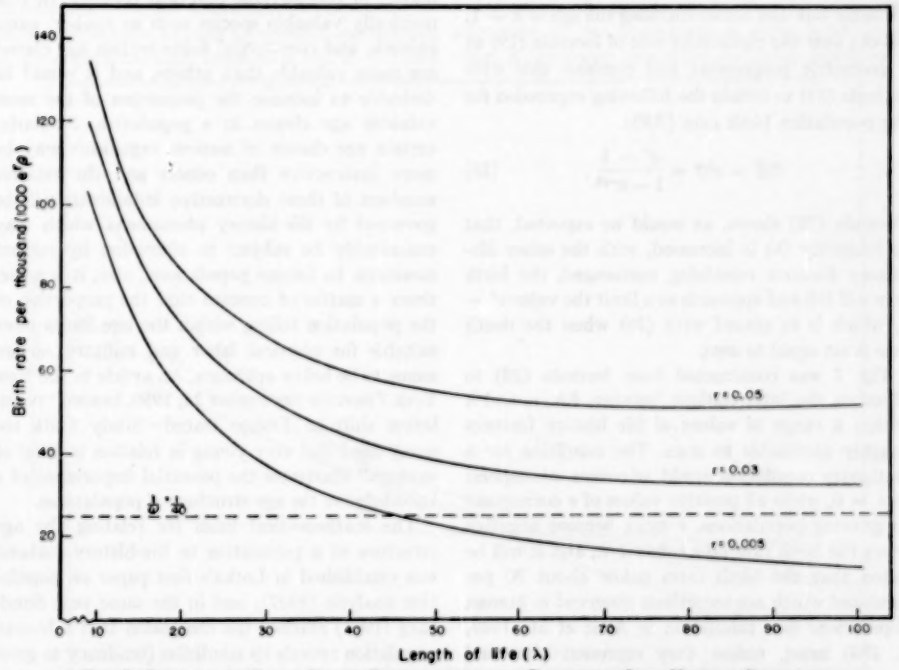

FIG. 7. POPULATION BIRTH RATES CORRESPONDING TO DIFFERENT LIFE HISTORY PATTERNS

The figure shows that the intrinsic rate of natural increase (r), the birth rate, and mean longevity (λ) are all interdependent. The broken line represents the minimum birth rate which would maintain a population if females did not survive beyond the age of 40 "years," which is here used as an estimate of the normal age (ω) at which reproduction is concluded. As longevity is increased, slow population growth becomes possible even when birth rates fall below $1/\omega$. Such low birth rates, however, have sometimes caused unwarranted concern about excessive population increase when abnormal conditions have temporarily reduced the death rate so that there is a large excess of births over deaths.

designate as a minimum maintenance birth rate the value $1/\omega$, or 0.025 in the case of man. But it is clear from the foregoing sections that offspring produced prior to the time that a female reaches the age of 40 will already have begun to "accumulate interest" before the mother can reach the age of 100. The compound interest nature of potential population growth complicates the relationship between birth rate and life-history phenomena and makes it conceivable that populations of species where $\lambda > \omega$ could even continue to grow while exhibiting birth rates lower than $1/\omega$.

No end of interesting combinations of birth rates, death rates, and life-history phenomena might merit consideration, but a single simple example will be selected here to illustrate the general relationship between changing longevity and population birth-rates. If we assume, as before, a physiological type of survivorship such that each individual that is born lives to attain its λth birthday but dies before reaching the age of $\lambda + 1$, we can sum the right-hand side of formula (19) as a geometric progression and combine this with formula (27) to obtain the following expression for the population birth rate (BR):

$$BR = e^r\beta = \frac{e^r - 1}{1 - e^{-r\lambda}}. \qquad (28)$$

Formula (28) shows, as would be expected, that as longevity (λ) is increased, with the other life-history features remaining unchanged, the birth rate will fall and approach as a limit the value $e^r - 1$, which is in accord with (26) when the death rate is set equal to zero.

Fig. 7 was constructed from formula (28) to illustrate the interrelations between BR, r, and λ within a range of values of life history features roughly applicable to man. The condition for a stationary population would, of course, correspond to $r = 0$, while all positive values of r correspond to growing populations. r must become negative when the birth rate falls below $1/\lambda$, and it will be noted that the birth rates below about 20 per thousand which are sometimes observed in human populations (see tabulation in Allee et al., 1949, p. 288) must, unless they represent abnormal temporary phenomena, correspond to populations with very low potential growth rates. The curve for $r = .005$, in fact, does not differ greatly from $1/\lambda$. The curves in Fig. 7 flatten out rapidly for large values of λ, so that drastic and generally unattainable increases in longevity would be required to make such low birth rates compatible with appreciable population growth.

Looking at these relationships from a different point of view, Fig. 7 shows that a reduction in longevity, such as might result from reducing the life expectancy of game animals, can be expected to result in an increased birth rate even if the intrinsic rate of increase is unchanged. It does not seem worthwhile at present to attempt a quantitative estimate of these relationships because the assumption of a physiological type of survivorship curve is probably not even approximately true for game animals. When more realistic estimates of survivorship are available, however, the type of relationship illustrated in Fig. 7 may assume practical importance.

THE STABLE AGE DISTRIBUTION

The age structure of a population often is a matter of considerable practical concern. In economically valuable species such as timber, game animals, and commercial fishes certain age classes are more valuable than others, and it would be desirable to increase the proportion of the most valuable age classes in a population. Similarly, certain age classes of noxious organisms may be more destructive than others and the relative numbers of these destructive individuals will be governed by life-history phenomena which may conceivably be subject to alteration by control measures. In human populations, also, it is sometimes a matter of concern that the proportion of the population falling within the age limits most suitable for physical labor and military service seems to be below optimum. An article in the New York *Times* for September 24, 1950, headed "population shift in France traced—Study finds too many aged and very young in relation to total of workers" illustrates the potential importance of a knowledge of the age structure of populations.

The mathematical basis for relating the age structure of a population to life-history features was established in Lotka's first paper on population analysis (1907); and in the same year Sundbärg (1907) reached the conclusion that a human population reveals its condition (tendency to grow or decline) through its age structure. These important conclusions have not been sufficiently noted by ecologists. When the mortality factors affecting a population are altered either through natural environmental changes or through human exploitation or attempts at control there will in

general result a change in the age structure of the population, and this may be observable even before changes in population size or in birth rates provide evidence of the consequences of the changed mortality factors. The subject of age structure is a large and difficult one because the various combinations of life-history features, birth rates, death rates, and age structure are analogous to a multi-dimensional figure where a change imposed in any one feature induces changes in all of the others. The subject has been considered most in connection with human populations, and some empirical generalizations have been obtained which may profitably be examined by means of the computational methods we have been employing. For the purpose of illustrating the general character of the relationships involved, one species will serve as well as another.

For illustrative purposes we may proceed as in the preceding sections and consider the stable age distribution for cases where survivorship is of the physiological type. Letting c_x represent the fraction of the population aged between x and $x + 1$, we may employ formulas (5) and (28) directly to obtain, for $x < \lambda$:

$$c_x = \frac{e^{-rx}(1 - e^{r})}{1 - e^{-r\lambda}}. \tag{29}$$

From formula (29) it is apparent that if the extreme longevity for a population is altered without changing the intrinsic rate of increase, the effect on the age structure will be of a very simple type. An increase in longevity from λ_1 to λ_2 will simply reduce the proportion of the population in each age category below λ_1 by the constant proportion $\frac{1 - e^{-r\lambda_1}}{1 - e^{-r\lambda_2}}$. Consequently, the effect will be most noticeable on the youngest age classes, because these are the largest classes.

Changes in the value of r affect the stable age distribution in a more complex way than do changes in λ, although the general result of increasing the value of r will be to increase the proportion of young in the population, with a corresponding decrease in the proportion of older individuals. Fig. 8 illustrates this effect for three values of r,

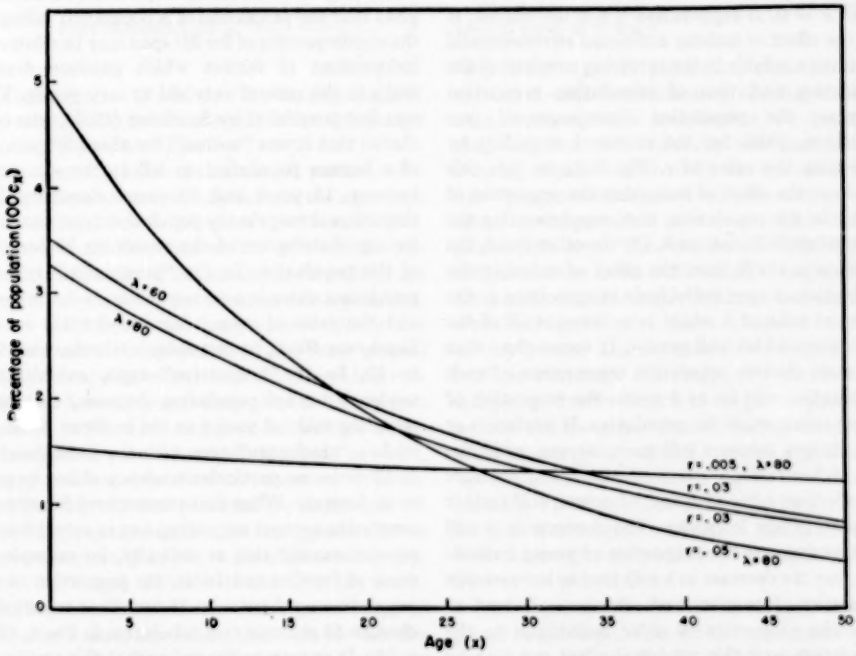

FIG. 8. THE STABLE AGE DISTRIBUTION, OR PROPORTION OF THE POPULATION FALLING WITHIN EACH INTERVAL OF AGE, IS SHOWN HERE AS A FUNCTION OF THE INTRINSIC RATE OF INCREASE (r) AND THE LENGTH OF LIFE (λ)

These relationships have important ecological correlaries. See text for a discussion relating these to the "optimum yield" problem.

assuming that λ in formula (29) remains constant at 80 "years."

The way in which population age-structure is affected by changes in the value of r and λ, as illustrated by formula (29) and Fig. 8, permits some qualitative conclusions which are of interest in connection with the "optimum yield problem" (for discussion, see Allee et al., 1949, p. 377). If man (or some other species) begins exploitation of a previously unexploited population, the age structure will be affected in a definite manner. An obvious result of increased predation will be to decrease the average longevity, corresponding to a decrease in λ. We have seen earlier (Fig. 7) that this will ordinarily have the effect of increasing the population birth rate, and Fig. 8 and formula (29) show that another effect will be to increase the proportion of young in the population, the very youngest age classes being most affected. However, the increased mortality may also affect the value of r. If the population is initially in equilibrium with the capacity of its environment, its total life history pattern will be adjusted to the effective value, $r = 0$. If exploitation is not too intense, it has the effect of making additional environmental resources available to the surviving members of the population and thus of stimulating population increase; the population "compensates" (see Errington, 1946) for the increased mortality by increasing the value of r. Fig. 8 shows that this will have the effect of increasing the proportion of young in the population, thus supplementing the effect of exploitation on λ. On the other hand, the increase in r will have the effect of reducing the proportion of aged individuals in opposition to the effect of reduced λ which is to increase all of the age classes which still persist. It seems clear that the most obvious population consequence of such exploitation will be to increase the proportion of young members of the population. If predation or exploitation becomes still more intense, as in the case of "overfishing" (Russell, 1942), it will reduce the effective value of r, and, of course, still further reduce average longevity. The decrease in r will tend to decrease the proportion of young individuals, but the decrease in λ will tend to increase this proportion. However, both changes will tend to raise the proportion of older individuals in the population, and this combined effect can then be expected to be the most obvious corollary of overfishing. These conclusions, of course, greatly oversimplify a complex phenomenon. In order to make quantitative estimates of these effects it would be necessary to have detailed information about the life-history features, especially survivorship under the conditions of increased predation. Nevertheless, these qualitative conclusions show the type of effect to be expected when populations are subjected to increased predation, and they suggest that observations of the changes in the age structure of populations may provide valuable evidence of over-exploitation, or, from the opposite point of view, of the effectiveness of control measures. Bodenheimer (1938) comments on the fact that ecologists have neglected this important subject.

From Fig. 8 it will be noticed that changes in life-history features produce their greatest effects on the extreme age classes, whereas the curves representing different patterns are close together in the "middle" age range. The same phenomenon is evident, for example, in a graph (Fig. 27) reproduced by Dublin, Lotka, and Spiegelman (1949) from Lotka (1931) to show the age structure of human populations corresponding to stationary, increasing, and decreasing populations. This suggests that the proportion of a population falling in the middle portion of the life span may be relatively independent of factors which produce drastic shifts in the ratio of very old to very young. This was first postulated by Sundbärg (1907), who concluded that it was "normal" for about 50 per cent of a human population to fall in the age range between 15 years and 50 years. Sundbärg distinguishes three primary population types based on the age distribution of the remaining 50 per cent of the population. In the "progressive" type of population there is a strong tendency for increase and the ratio of young (aged under 15) to old (aged over 50) is, by Sundbärg's criteria, about 40 to 10. In the "regressive" type, exhibiting a tendency toward population decrease, the corresponding ratio of young to old is about 20 to 30, while a "stationary" type with the ratio about 33 to 17 shows no particular tendency either to grow or to decrease. When first encountered Sundbärg's conclusion appears surprising, but in actual human populations differing as radically, for example, as those of Sweden and India, the proportion of the population aged between 15 and 50 is remarkably close to 50 per cent (see tabulation in Pearl, 1946, p. 78). It appears to the writer that this conclusion should be of great interest to students of human populations. The age class between 15 and 50 years includes the bulk of the workers and persons of

military age, and Sundbärg's conclusion implies that the size of this class relative to the remainder of the population must be determined by life-history features which cannot readily be deliberately controlled.

For other species also, the life span may be meaningfully divided into three primary age classes, pre-reproductive (aged 0 to α), reproductive (aged α to ω), and post-reproductive (aged ω to λ), which differ considerably in their biological significance. If we continue with our assumption of physiological survivorship we can obtain the relative sizes of these three age classes directly from formula (29), and Sundbärg's generalization offers an interesting empirical pattern with which to compare our results. For the relative sizes of the three fundamental age classes formula (29) gives:

$$\left.\begin{aligned}\text{Pre-reproductive} &= \frac{1 - e^{-r\alpha}}{1 - e^{-r\lambda}} \\ \text{Reproductive} &= \frac{e^{-r\alpha} - e^{-r\omega}}{1 - e^{-r\lambda}} \\ \text{Post-reproductive} &= \frac{e^{-r\omega} - e^{-r\lambda}}{1 - e^{-r\lambda}}\end{aligned}\right\} \quad (30)$$

By putting $\alpha = 15$ and $\omega = 50$, we may examine the relationship between r and λ for Sundbärg's primary population types.

The generalization that about 50 per cent of a human population normally falls in the age range from 15 to 50 is in accord with formulas (30). When $r = .03$ the value of λ to give a stable age distribution with just 50 per cent in the middle age range would be 59 years, but an increase in longevity to 85 years would only reduce this class to 45 per cent of the population. The same general conclusion applies when r is small. The values $r = .005$ and $\lambda = 63$ years correspond to 55 per cent aged 15 to 50 years, and λ would have to be increased to 81 years to reduce this to 45 per cent. It appears that over the usual range of values of human longevity and potential population growth Sundbärg's generalization is very good. This is shown graphically in Fig. 9. It is noteworthy that when the length of life is about 70 years, Sundbärg's generalization holds over a wide range of values of r. In other words, this ratio of "middle-aged" to total population is quite insensitive to changes in other life history features.

Figure 9 illustrates Sundbärg's population criteria for values of $r > 0$. It is clear that the

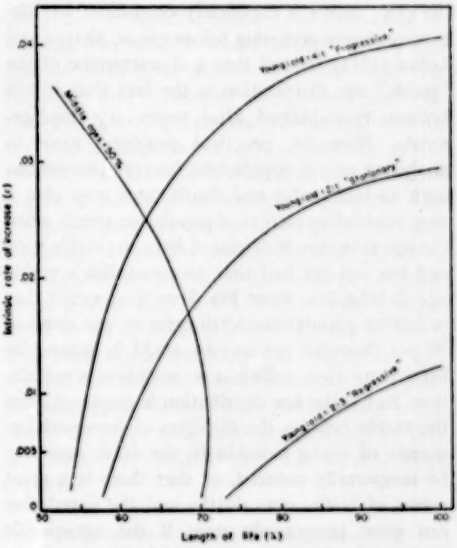

FIG. 9. SUNDBÄRG'S POPULATION CRITERIA IN RELATION TO LIFE-HISTORY FEATURES

The "middle age" range here consists of individuals aged 15 years to 50 years.

"regressive" type of population structure is not consistent with populations possessing a strong tendency to increase and, in fact, for usual longevity figures, will ordinarily correspond to decreasing populations ($r < 0$). On the other hand, the "progressive" type of structure does correspond to large values of r even when λ is not particularly large. The "stationary" type of population structure is less well defined. Any population for which the life-history features correspond to $r > 0$ will tend to grow, and the ratio of two "old" to one "young" can correspond to a large value of r when λ is large. The value of r is, of course, independent of the length of the post-reproductive part of the life span, whereas the age structure is not. For any given value of r, which is determined by the life-history features of individuals aged below ω, the effect of an increase in longevity will be to decrease the proportion of young and, to a lesser extent, the proportion of reproductive members of the population.

At first glance, the type of interactions shown in Fig. 9 might suggest that if the age structure of a population were artificially shifted in the "regressive" direction, for example, through migration or improvements in public health, there would result a reduction in the value of r. This, however, is not

the case, since r is completely determined by life-history events occurring before age ω. Sharpe and Lotka (1911) showed that a characteristic of the "stable" age distribution is the fact that it will become reestablished after temporary displacements. However, practical problems arise in analyzing actual populations because phenomena such as birth rates and death rates may give a very misleading picture of population trends when the age structure is displaced from the stable type and has not yet had time to reestablish a stable age distribution. From Fig. 7 we have noted that in human populations birth rates on the order of 20 per thousand per annum would in general be little more than sufficient to maintain a population. But if the age distribution is displaced from the stable type in the direction of increased frequency of young individuals, the death rate may be temporarily reduced, so that there is a great excess of births over deaths and the population can grow temporarily even if the age-specific birth rates are too low to maintain the population permanently at a constant size. Under these conditions the population is "aging," and in human populations this phenomenon has a number of interesting and important corollaries (see Dublin, Lotka, and Spiegelman, 1949). Fisher (1930) has considered the problem in a more general sense, noting that the apparent value of r given by formula (3) will be incorrect when the age structure is displaced. Fisher suggests the possibility of measuring population size not in terms of the number of individuals present but in terms of "reproductive value," where the "value" of an individual represents his remaining potentialities for contributing to the ancestry of future generations. Some such approach has great potential value for ecological studies of natural populations, but its possibilities in this direction seem not yet to have been explored.

EMPIRICAL APPLICATIONS

In the preceding sections we have been concerned with the influence of specific life-history patterns on the characteristics of populations. In order to examine these effects we have made simplifying assumptions by regarding some of the life-history features as fixed in a certain way while we examined the results of varying other features. While this procedure oversimplifies the biological situation as it exists in actual populations, the writer regards it as a sound way of investigating the meaning of life-history features. The same general attitude may be traced back to Robert Wallace (1753) in his book which profoundly influenced Malthus. Wallace pointed out that "mankind do not actually propagate according to the rules in our tables, or any other constant rule . . ." but he emphasized that tables of potential population growth are still valuable because they permit us to evaluate the influences restraining population growth.

Wallace, then, was a pioneer in appreciating the potential value of comparisons between empirical and theoretical population phenomena. In modern actuarial practice, population data are subjected to involved mathematical treatments which are sometimes considered to represent biological laws and at other times to be merely empirical equations, but which, in any case, are known to yield results of practical value. In the words of Elston (1923, p. 68):

> ". . . it seems to me that even though there be governing causes of mortality that may result in a true law of mortality, any group of lives studied is so heterogeneous, due to differences in occupation, climate, sanitary conditions, race, physical characteristics, etc., that any formula must in practice be considered to be merely a generalization of what is actually happening."

The number of different combinations of life-history features of the type we have been discussing is essentially infinite, and it is out of the question to make detailed examinations of any great proportion of these from the theoretical standpoint. However, we have seen that certain population features, such as the prevailing age distribution and the intrinsic rate of increase, summarize a great deal of information about the potentialities of the population and its relationship to its particular and immediate environment. As mentioned earlier, the recent ecological literature demonstrates that ecologists are becoming interested in determining such features as the intrinsic rate of increase for non-human populations. These computations may have practical value in dealing with valuable or noxious species, and they possess great theoretical interest for ecologists. For example, the logistic equation has been widely employed to represent population growth in a variety of organisms (Allee et al., 1949; Pearl, 1927); and it has also been attacked (Yule, 1925; and succeeding discussion, Gray, 1929; Hogben, 1931; Smith, 1952), on the grounds that it is too versatile and can be made to fit empirical data that might arise from entirely different "laws" of population

growth. This criticism is, of course, directed at the fact that the curve-fitter has three arbitrary constants at his disposal in seeking to obtain a good fit. One of these constants is r, the intrinsic rate of increase. The grounds for accepting or rejecting the logistic equation as a law of population growth (or for seeking some other law) would be greatly strengthened if the value of r was computed directly from observed life-history features and independently of the data on population size.

The computational methods employed in the preceding sections suggest several possible ways of computing the value of r from empirical life-history data. The usual procedure for such computations has been a tedious one based on formula (3) (see Lotka's appendix to Dublin and Lotka, 1925), although Birch (1948) employed formula (17) as an approximation to (3) for his computations. The methods discussed in the preceding sections suggest that a logical procedure for obtaining an empirical value of r would be to observe age-specific birth rates and survivorship under the environmental conditions of interest, and from these to write a "generation law" so that formula (11) can be employed. The single positive root of (11) is e^r and this can be estimated to any desired degree of accuracy without great difficulty even for species where the reproductive life is prolonged. When one is actually solving equation (11) it is strikingly brought to one's attention that the final terms representing reproduction in later life are relatively unimportant in influencing the value of r. This once again reinforces our conclusion that reproduction in early life is of overwhelming importance from the population standpoint, and should be much more carefully observed in field and laboratory studies than has usually been the case.

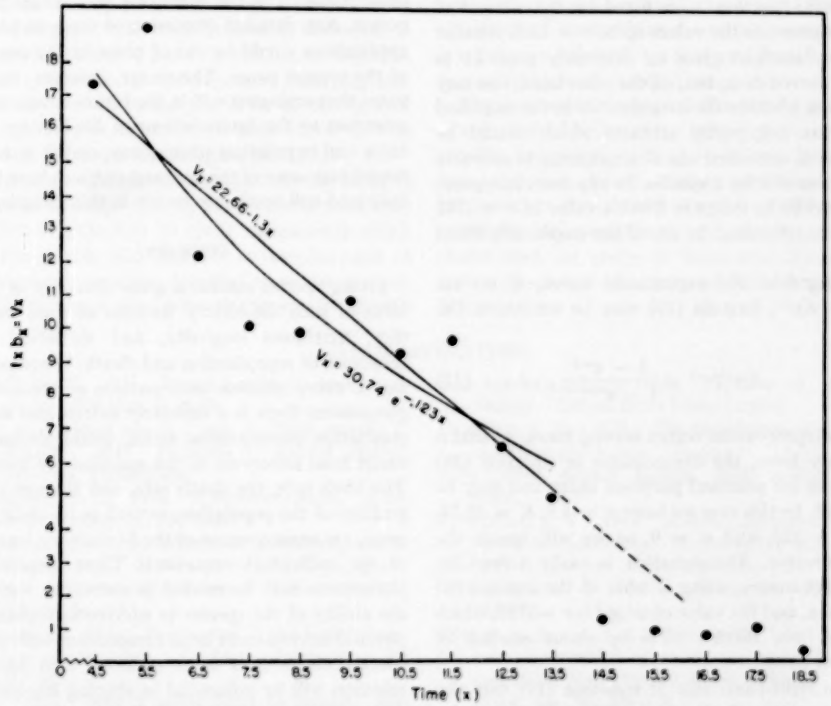

FIG. 10. A STRAIGHT LINE AND AN EXPONENTIAL FUNCTION FITTED TO THE DATA OF BIRCH (1948)

These data are suitable only for illustrating computational methods. Birch observed the age-specific fecundity rates (b_x) for the rice weevil *Calandra oryzae* living under constant conditions of temperature and moisture. He did not observe survivorship (l_x) but carried over the shape of the survivorship curve from the flour beetle *Tribolium confusum*. The black dots represent the product $l_x b_x$.

An alternative approach for obtaining empirical values of r consists of fitting the V_x ($= l_x b_x$) values with mathematical curves of types which make it possible either to obtain the sum of the series on the right-hand side of equation (19) or to employ Laplace transformations to solve equations (3) or (20) by simple iterative methods. Different formulas could be fitted to different sections of the V_x curve, and, when good fits can be obtained with combinations of straight lines, step-functions, exponential functions, and other simple formulas, this procedure will often lead to easy ways of solving for r. As a very simple example of this procedure we may consider the data of Birch (1948), for which he employed formula (17) and, by computations which are given in detail in his paper, obtained the value $r = 0.762$.

The V_x data employed by Birch are shown graphically in Fig. 10 by means of the black dots. The two curves, a straight line and a simple exponential function, were fitted by the method of least squares to the values up to $x = 13.5$. Neither of the functions gives an extremely good fit to the observed data, but, on the other hand, one may question whether the irregularities in the empirical data are not partly artifacts which should be smoothed out when one is attempting to estimate the value of r for a species. In any case, it appears worthwhile to compare Birch's value of $r = .762$ with that obtained by use of the empirically fitted curves.

Using first the exponential curve, if we set $V_x = Ke^{\alpha x}$, formula (19) may be written in the form:

$$Ke^{\alpha(a-r)} = \frac{1 - e^{a-r}}{1 - e^{n(a-r)}}. \qquad (31)$$

When reproduction occurs several times, so that n is fairly large, the denominator in equation (31) becomes for practical purposes unity and may be ignored. In this case we have $\alpha = 4.5$, $K = 30.74$, $a = -.123$, and $n = 9$, so we will ignore the denominator. The equation is easily solved by iterative means, using a table of the exponential function, and the value obtained is $r = .758$, which differs from Birch's value by about one-half of one per cent.

The right-hand side of equation (19) can also be summed for the linear case where $V_x = a + bx$, but in this case the Laplace transformation employed with formula (3) yields a slightly simpler equation:

$$\frac{ar + b}{r^2} = e^{\alpha}. \qquad (32)$$

Putting $a = 22.66$, $\alpha = 4.5$, and $b = -1.3$ in equation (32), and solving by iterative means we obtain $r = .742$, which differs from Birch's value by nearly three per cent, although this seems to be good agreement in view of the crude approximations employed.

In many practical applications dealing with natural and experimental populations some approximation to the value of r such as those presented above may be all that can be justified by the accuracy of the data. The estimate of r could undoubtedly be improved by fitting different portions of the V_x curve with different functions. Another refinement suggested by observations presented earlier in this paper would be to fit the empirical curves by a method which would give greater weight to the earlier points which have more influence on the value of r than do the later points. Any detailed discussion of these empirical applications would be out of place in the context of the present paper. The writer, however, anticipates that ecologists will in the future devote more attention to the interrelations of life-history features and population phenomena, and it is to be hoped that some of the approaches which have been indicated will accelerate trends in this direction.

SUMMARY

Living species exhibit a great diversity of patterns of such life-history features as total fecundity, maximum longevity, and statistical age schedules of reproduction and death. Corresponding to every possible such pattern of life-history phenomena there is a definitely determined set of population consequences which would ultimately result from adherence to the specified life history. The birth rate, the death rate, and the age composition of the population, as well as its ability to grow, are consequences of the life-history features of the individual organisms. These population phenomena may be related in numerous ways to the ability of the species to survive in a changed physical environment or in competition with other species. Hence it is to be expected that natural selection will be influential in shaping life-history patterns to correspond to efficient populations.

Viewed in this way, comparative studies of life histories appear to be fully as meaningful as studies of comparative morphology, comparative

psychology, or comparative physiology. The former type of study has, however, been neglected from the evolutionary point of view, apparently because the adaptive values of life-history differences are almost entirely quantitative. The recent ecological literature does show a trend toward the increasing application of demographic analysis to non-human populations, but the opposite approach of deducing demographic consequences from life-history features has been relatively neglected. The present paper is presented with the hope that this situation can be changed. In other fields of comparative biology it is usual to examine individual characteristics and to regard these as possible adaptations, and the writer believes that life-history characteristics may also be profitably examined in this way.

It is possible by more or less laborious methods to compute the exact size and composition of the population which at any future time would be produced by any given initial population when the life-history pattern of the individual organisms is regarded as fixed. Thus it is possible to make an exact evaluation of the results of changing any life-history feature, and the value of this type of analysis may be apparent to those biologists who distrust the usual demographic procedures.

Starting with exact computational methods, it has been shown that early population growth may exhibit irregularities or cyclic components which are identifiable with negative or complex roots of an algebraic equation, but that these components vanish in time so that potential population growth is ultimately a geometric progression. Having established this fact, it is shown that the exact computational methods and the more convenient approximate methods lead to identical conclusions when considered over the long time scale which is of interest in adaptational and evolutionary considerations.

Some life-history patterns of ecological interest are examined and compared by means of relatively simple formulas derived from a consideration of the form of potential population growth. The results have bearing on the possible adaptive value of genetically induced changes of life-history features. It is suggested that this type of approach may add to the value of life-history studies and that an awareness of the possible meanings of empirical life-history data may aid in planning such studies by insuring that all pertinent information will be recorded. One of the most striking points revealed by this study is the fact that the age at which reproduction begins is one of the most significant characteristics of a species, although it is a datum which is all too frequently not recorded in the literature of natural history.

The number of conceivable life-history patterns is essentially infinite, if we judge by the possible combinations of the individual features that have been observed. Every existing pattern may be presumed to have survival value under certain environmental conditions, and the writer concludes that the study of these adaptive values represents one of the most neglected aspects of biology.

LIST OF LITERATURE

ALLEE, W. C. 1934. Recent studies in mass physiology. *Biol. Rev.*, 9: 1–48.

——, A. E. EMERSON, O. PARK, T. PARK, and K. P. SCHMIDT. 1949. *Principles of Animal Ecology*. Saunders, Philadelphia.

ARCHIBOLD, R. C. 1918. A Fibonacci series. *Amer. math. Monthly*, 25: 235–238.

BANTA, A. M., T. R. WOOD, L. A. BROWN, and L. INGLE. 1939. Studies on the physiology, genetics, and evolution of some Cladocera. *Publ. Carneg. Inst.*, 39.

BERKSON, J. 1944. Application of the logistic function to bio-assay. *J. Amer. statist. Ass.*, 39: 357–365.

——. 1951. Why I prefer logits to probits. *Biometrics*, 7: 327–329.

BIRCH, L. C. 1948. The intrinsic rate of natural increase of an insect population. *J. Anim. Ecol.*, 17: 15–26.

BODENHEIMER, F. S. 1938. *Problems of Animal Ecology*. Oxford Univ. Press, London.

CHAPMAN, R. N. 1928. The quantitative analysis of environmental factors. *Ecology*, 9: 111–122.

——. 1938. *Animal Ecology*. McGraw-Hill, New York.

CHURCHILL, R. V. 1944. *Modern Operational Mathematics in Engineering*. McGraw-Hill, New York.

DEEVEY, E. S., JR. 1947. Life tables for natural populations of animals. *Quart. Rev. Biol.*, 22: 283–314.

DUBLIN, L. I., and A. J. LOTKA. 1925. On the true rate of natural increase as exemplified by the population of the United States, 1920. *J. Amer. statist. Ass.*, 20: 305–339.

——, ——, and M. SPIEGELMAN. 1949. *Length of Life. A Study of the Life Table*, rev. ed. Ronald Press, New York.

DUNKEL, O. 1925. Solutions of a probability differ-

ence equation. *Amer. math. Monthly*, 32: 354–370.

ELSTON, J. S. 1923. Survey of mathematical formulas that have been used to express a law of mortality. *Rec. Amer. Inst. Actuar.*, 12: 66–95.

ERRINGTON, P. L. 1946. Predation and vertebrate populations. *Quart. Rev. Biol.*, 21: 144–177, 221–245.

EVANS, F. C., and F. E. SMITH. 1952. The intrinsic rate of natural increase for the human louse, *Pediculus humanus* L. *Amer. Nat.*, 86: 299–310.

FIBONACCI, L. (1857). *Liber Abbaci di Leonardo Pisano publicati da Baldasarre Boncompagni*. Tipografia delle Scienze mathematiche e fisiche, Roma.

FINNEY, D. J. 1947. The principles of biological assay. *J. R. statist. Soc.*, 109: 46–91.

——. 1949. The choice of a response metameter in bio-assay. *Biometrics*, 5: 261–272.

FISHER, R. A. 1930. *The Genetical Theory of Natural Selection*. Oxford Univ. Press, London.

FRANK, P. W. 1952. A laboratory study of intraspecies and interspecies competition in *Daphnia pulicaria* (Forbes) and *Simocephalus vetulus* O. F. Müller. *Physiol. Zool.*, 25: 178–204.

FRANKLIN, B. 1751. Observations concerning the increase of mankind and the peopling of countries. In *The Works of Benjamin Franklin*, ed. by J. Sparks, 1836, Vol. 2: 311–321. Hilliard, Grey, Boston.

GAUSE, G. F. 1934. *The Struggle for Existence*. Williams & Wilkins, Baltimore.

GOMPERTZ, B. 1825. On the nature of the function expressive of the law of human mortality. *Phil. Trans.*, 36: 513–585.

GRAUNT, J. 1662. *Natural and Political Observations Mentioned in a Following Index and Made upon the Bills of Mortality*.... Printed by T. Roycroft, London.

GRAY, J. 1929. The kinetics of growth. *Brit. J. exp. Biol.*, 6: 248–274.

HOGBEN, L. 1931. Some biological aspects of the population problem. *Biol. Rev.*, 6: 163–180.

HUMPHREYS, W. J. 1929. *Physics of the Air*, 2nd ed. McGraw-Hill, New York.

HUTCHINSON, G. E. 1948. Circular causal systems in ecology. *Ann. N. Y. Acad. Sci.*, 50: 221–248.

HYMAN, L. H. 1951. *The Invertebrates. Vol. 2. Platyhelminthes and Rhynchocoela. The Acoelomate Bilateria*. McGraw-Hill, New York.

JACKSON, C. H. N. 1939. The analysis of an animal population. *J. Anim. Ecol.*, 8: 238–246.

JORDAN, C. 1950. *Calculus of Finite Differences*, 2nd ed. Chelsea, New York.

KOSTITZIN, V. A. 1939. *Mathematical Biology*. Harrap, London.

KUCZYNSKI, R. R. 1932. *Fertility and Reproduction*. Falcon Press, New York.

——. 1935. *The Measurement of Population Growth*. Sidgwick & Jackson, London.

LESLIE, P. H., and R. M. RANSON. 1940. The mortality, fertility, and rate of natural increase of the vole (*Microtus agrestis*) as observed in the laboratory. *J. Anim. Ecol.*, 9: 27–52.

——, and T. PARK. 1949. The intrinsic rate of natural increase of *Tribolium castaneum* Herbst. *Ecology*, 30: 469–477.

LINNAEUS, C. 1743. Oratio de telluris habitabilis. In *Amoenitates Academicae seu Dissertationes Variae*.... Editio tertia curante J. C. D. Schrebero, 1787, Vol. 2: 430–457. J. J. Palm, Erlangae.

LOTKA, A. J. 1907a. Relation between birth rates and death rates. *Science*, 26: 21–22.

——. 1907b. Studies on the mode of growth of material aggregates. *Amer. J. Sci.*, 24: 119–216.

——. 1910. Contributions to the theory of periodic reactions. *J. phys. Chem.*, 14: 271–274.

——. 1925. *Elements of Physical Biology*. Williams & Wilkins, Baltimore.

——. 1927. The size of American families in the eighteenth century and the significance of the empirical constants in the Pearl-Reed law of population growth. *J. Amer. statist. Ass.*, 22: 154–170.

——. 1931. The structure of a growing population. *Human Biol.*, 3: 459–493.

——. 1934. *Théorie Analytique des Associations Biologiques*. Hermann, Paris.

LOWAN, A. N., Technical director. 1941. *Table of Natural Logarithms*. 4 vols. Federal Works Agency, Works Projects Administration for the City of New York. Rept. of Official Project No. 15-2-97-33.

MALTHUS, T. R. 1798. *An Essay on the Principle of Population as it Affects the Future Improvement of Society, with Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers*. Printed for J. Johnson in St. Paul's Churchyard, London.

MENDES, L. O. 1949. Determinação do potencial biotico da "broca do café"—*Hypothenemus hampei* (Ferr.)—e consideracões sôbre o crescimento de sua população. *Ann. Acad. bras. Sci.*, 21: 275–290.

MILNE-THOMPSON, L. M. 1933. *The Calculus of Finite Differences*. Macmillan, London.

MOLISCH, H. 1938. *The Longevity of Plants*. E. H. Fulling, Lancaster Press, Lancaster, Pa.

NEWMAN, F. W. 1883. Table of the descending exponential function to twelve or fourteen places of decimals. *Trans. Camb. phil. Soc.*, 13: 145–241.

NICHOLSON, A. J., and V. A. BAILEY. 1935. The balance of animal populations. Part I. *Proc. zool. Soc. Lond.*, 1935: 551–598.

PEARL, R. 1925. *The Biology of Population Growth*. Knopf, New York.

——. 1930. *Introduction to Medical Biometry and Statistics*, 2nd ed. Saunders, Philadelphia.

——. 1937. On biological principles affecting populations: human and other. *Amer. Nat.*, 71: 50–68.

——. 1939. *The Natural History of Population.* Oxford Univ. Press, London.

——. 1946. *Man the Animal.* Principia Press, Bloomington, Ind.

——, and L. J. Reed. 1920. On the rate of growth of the population of the United States since 1790 and its mathematical representation. *Proc. natl. Acad. Sci. Wash.*, 6: 275–288.

——, and J. R. Miner. 1935. Experimental studies on the duration of life, XIV. The comparative mortality of certain lower organisms. *Quart. Rev. Biol.*, 10: 60–79.

Pierce, J. C. 1951. The Fibonacci series. *Sci. Monthly*, 73: 224–228.

Quetelet, A. 1835. *Sur l'Homme et le Développment de ses Facultés ou Essai de Physique Sociale.* Bachelier, Imprimeur-Libraire, Paris.

Rhodes, E. C. 1940. Population mathematics. *J. R. statist. Soc.*, 103: 61–89, 218–245, 362–387.

Ricker, W. E. 1948. *Methods of Estimating Vital Statistics of Fish Populations.* Indiana Univ. Pubs. Sci. Ser., 15, Bloomington.

Ross, R. 1911. *The Prevention of Malaria*, 2nd ed. Dutton, New York.

Russell, E. S. 1942. *The Overfishing Problem.* Cambridge Univ. Press, Cambridge.

Sadler, M. T. 1830. *The Law of Population: A Treatise, in Six Books; in Disproof of the Superfecundity of Human Beings, and Developing the Real Principle of their Increase.* Murray, London.

Salt, G. 1936. Experimental studies in insect parasitism. IV. The effect of superparasitism on populations of *Trichogramma evanescens*. *Brit. J. exp. Biol.*, 13: 363–375.

Sharpe, F. R., and A. J. Lotka. 1911. A problem in age distribution. *Phil. Mag.*, 21: 435–438.

Smith, F. E. 1952. Experimental methods in population dynamics, a critique. *Ecology*, 33: 441–450.

Stangeland, C. E. 1904. *Pre-Malthusian Doctrines of Population; a Study in the History of Economic Theory.* Columbia Univ. Stud. Hist. Econ. pub. Law, Vol. 21, no. 3.

Sundbärg, A. G. 1907. *Bevölkerungsstatistik Schwedens 1750–1900.* P. A. Norstedt and Söner, Stockholm.

Thompson, D'Arcy W. 1942. *On Growth and Form*, new ed. Cambridge Univ. Press, Cambridge.

Thompson, W. R. 1931. On the reproduction of organisms with overlapping generations. *Bull. ent. Res.*, 22: 147–172.

——. 1939. Biological control and the theories of the interactions of populations. *Parasitology*, 31: 299–388.

U. S. Forest Service. 1948. The woody-plant seed manual. *Misc. Publ. U. S. Dep. Agric.*, No. 654.

Verhulst, P. F. 1838. Notice sur la loi que la population suit dans son accroisissement. *Corresp. math. phys., A. Quetelet*, 10: 113–121.

——. 1845. Recherches mathématiques sur la loi d'accroissement de la population. *Mém. Acad. R. Belg.*, 18: 1–38.

Volterra, V. 1927. Variazioni e fluttuazioni del numero d'individui in specie animali conviventi. *Mem. Accad. Lincei*, 324 (ser. sesta). Vol. 2.

——. 1931. Variation and fluctuations of the number of individuals in animal species living together. In *Animal Ecology* (Chapman, R. N.). McGraw-Hill, New York.

Wallace, R. 1753. *A Dissertation on the Numbers of Mankind in Antient and Modern Times: in which the Superior Populousness of Antiquity is Maintained.* Printed for G. Hamilton and J. Balfour, Edinburgh.

Wardle, R. A., and J. A. McLeod. 1952. *The Zoology of Tapeworms.* Univ. of Minnesota Press, Minneapolis.

Widder, D. V. 1940. *The Laplace Transform.* Princeton Univ. Press, Princeton.

——. 1947. *Advanced Calculus.* Prentice-Hall, New York.

Yule, G. U. 1906. On the changes in the marriage- and birth-rates in England and Wales during the past half century; with an inquiry as to their probable causes. *J. R. statist. Soc.*, 69: 88–132.

——. 1925. The growth of population and the factors which control it. *J. Roy. statist. Soc.*, 88: 1–58 (related discussions, pp. 58–90).

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not recieved it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

THE PREMEDICAL CURRICULUM

BY C. P. SWANSON

The Johns Hopkins University

A Review of PREPARATION FOR MEDICAL EDUCATION IN THE LIBERAL ARTS COLLEGE. *The Report of the Subcommittee on Preprofessional Education of the Survey of Medical Education.*

By Aura E. Severinghaus, Harry J. Carman, and William E. Cadbury, Jr. McGraw-Hill Book Company, New York, Toronto, and London. $4.50. xxiv + 400 pp. 1953.

There are few teachers in our liberal arts colleges who are not aware of the pressures and disturbances created in and by students who, while actually majors in one area or another of intellectual endeavor, are to all intents and purposes prostituting their educational opportunities to more immediate and baser ends. The necessity for this trend in our colleges today is often pointed out by both educators and students, but the expediency of it can have no justifiable basis. It is both dangerous and vicious, and, if allowed to continue, can only lead to the degradation of our liberal arts colleges from their supposed high place in our educational system to that level more rightly occupied by the trade schools. This point of view does not deny the value of the trade schools; rather, it insists that each school has different objectives which are attained in different ways. The development of prescribed curricula for preprofessional students in our liberal arts colleges—whether openly announced in college catalogs or privately endorsed by faculty advisors—profanes the meaning of a liberal education, and the publication of the present volume is ample evidence that the medical educators are not only aware of the developing trend but are militantly opposed to it as a discordant factor in the intellectual growth of those who are to practice the medical arts. Quite apart from the time and effort spent by conscientious instructors in getting their better students properly located in a suitable medical school—no mean consideration in itself—there are attitudes engendered in, and effects felt by, students who are so narrowly trained, and medical educators are cognizant of the need for corrective measures. Indeed, this trend must be profoundly disturbing to any faculty member who believes that a liberal education is something more than a practical and utilitarian preparation for a specific career.

Before we consider the purpose and contents of the present volume, it will be well to ask ourselves again the meaning and value of a liberal education. Although referred specifically to a university rather than a college, the words of John Masefield, quoted from the February, 1953, issue of *The Johns Hopkins Magazine*, take on a special meaning today. "There are few earthly things more beautiful than a university. It is a place where those who hate ignorance may strive to know, . . . where those who perceive the truth may strive to make others see, . . . where seekers and learners alike, banded together in the search for knowledge, will honor thought in all its finer ways, will welcome thinkers in distress or in exile, will uphold ever the dignity of thought and learning, and will exact standards in these things. They give to the young in their impressionable years the bond of a lofty purpose shared, . . . of a great corporate life whose links will not be loosed until they die. They give young people that close companionship for which youth longs, and that chance of the endless discussion of the themes which are endless—without which youth would seem a waste of time. There are few earthly things more splendid than a university. In these days of broken frontiers and collapsing values, . . . when the dams are down and the floods are making misery, when every future looks somewhat grim, and every ancient foothold has become something of a quagmire, . . . wherever a University stands, it stands and shines, . . . wherever it exists, the free minds of

men, urged on to full and fair enquiry, may still bring wisdom into human affairs."

These are things for the student to have and to hold; these are things which will set the pattern of thought and action, and dignify the purposes and ambitions of a chosen career. It is small wonder, therefore, that medical educators sound an alarm and seek to counteract the forces which tend to compress the liberal arts colleges, and inevitably its students, into an ever-narrowing mold. Can we, however, place the blame fairly on the student? I think not, for the student is simply adjusting himself to a situation that exists and that, in the face of intense competition, must be met head-on. Rather the blame must be borne by three groups which influence him most: (1) the society of which the student is a product, and which, with its customary short-sighted view, places a higher value on the social and economic advantages of a medical career than on the ennobling opportunities for humanitarian service; (2) the liberal arts colleges themselves, which have not been sufficiently strong to resist the pressures to convert their curricula into what is nothing more than a trade school preparation for a future career; and (3) the medical schools and the medical profession, which through their holier-than-thou attitude, their unvoiced but nonetheless rigidly enforced quota system, and their vigorously pursued trade union tactics have set up a caste of the scientific elite which cannot help but attract the impressionable student, qualified or unqualified.

These groups have combined unwittingly to produce an environment which, to say the very least, is highly undesirable: educationally, psychologically, and morally. The competition for grades takes precedence over all else, submerging, or at least distorting, the traditional meaning of a liberal arts education; the choice of courses is determined not by the student's interests but by the requirements of the various medical schools; the senior year, which should witness the culmination of all that has preceded it in college, is vitiated by the anxiety which arises over acceptance or rejection; finances are strained by the necessity of applying to many rather than to a few selected medical schools; moral values suffer when the student realizes that family ties and money so often play a role in acceptance and rejection. The top-flight student probably suffers less during this period than does the less brilliant man, but the emotional and mental wastage among students is far too great to countenance the present system.

It is too much to hope that society will alter its criteria of professional success. The rising costs of medical service will simply reinforce present attitudes. There are, however, many changes which the colleges and medical schools can make and which will alleviate some of the ills that now plague students, faculty, and schools. A companion volume, *Medical Schools in the United States at Mid-Century*, has dealt with the situation as it specifically applies to the medical side of education. The present book, which represents the findings of a two-year study of the curricula and methods of 115 liberal arts colleges by the Subcommittee on Preprofessional Education of the Survey of Medical Education, is aimed at the students and faculties of the colleges. Its approach is reasonable, the findings are reported and evaluated objectively, the recommendations are sound even though obvious, and it is to be hoped that its influence will be felt. The subcommittee has justified its task on the initial premise that the preprofessional education of the prospective medical student is of vital concern to medical educators, but it would not be unreasonable to suppose that additional reasons lie behind this extensive undertaking: first, that the average medical student today does not have the undergraduate education which best prepares him for a career in medicine; and second, that the medical schools themselves recognize that their own house is not in order, and that they, in part, are responsible for the fact that so many of the preprofessional students follow a preparatory course which inevitably will narrow rather than widen the horizons of their special profession. The medical man is too important a part of our social structure to be narrowly trained, for the profession will advance only when it is practiced by men of large minds and broad vision. A generous education which opposes early restriction of thought and action is much more likely to produce men of this caliber than that of the mere utilitarian practitioner. It should be recognized, however, that in making its recommendations, the subcommittee is simply adding its approval to a general change that is already in the air, for even industry, motivated as it is by practical considerations, has indicated a preference for the broadly trained and mentally flexible student, believing that it can more profitably and quickly provide on the job whatever specialization is necessary. Resistance to change is likely to be encountered from certain professional societies which, through an accreditation system, exert a profound and restrictive influence even to the Ph.D. level, but medical educators, as evidenced by this report, are taking a more enlightened view.

The recommendations of the subcommittee are eight in number:

1. No student should be denied the chance to prepare for a career in medicine because of color, religion, national origin, or economic status. This statement is cause for applause, but it is also a meaningless and hypocritical platitude so far as color and religion are concerned unless the same principle is extended to admittance to medical schools, membership in medical societies, and the right to practice in all hospitals. As to economic status, a different problem arises, and the only answer for the financially poor student is subsidization through scholarships. At present these are totally inadequate at the medical school level, although somewhat better at the college level. As a subsidiary recommendation, the committee also encourages the abolish-

ment of a vocational preference quota system, and the elimination of premedical curricula. There is, of course, no single curriculum which can claim superiority as a device for preparing the student for medical school; yet students themselves have a way of developing a set of courses which through the passage of time take on an aura of respectability and authority, a development which to a certain extent has its origin in the requirements for admission laid down by medical schools. It is the rare student who will follow his own dictates rather than those of a medical school, particularly if it is the one which he hopes to enter. As to the abolishment of a vocational quota system at the level of college admission, this is a more difficult problem than first meets the eye—and the subcommittee is well aware of it—for those universities which have both an undergraduate school and a medical school are besieged with applicants aspiring to a medical career. Unless care is taken, other areas of study suffer a serious loss of students, and the flow of ideas among students is inevitably restricted and depressed. One of the few ways of insuring an equitable distribution of students is the maintenance of an intelligent quota system, despite its inherent dangers.

2. The subcommittee advises the development of a good advisory system not only for the encouragement of the good student but for the rechannelling of the efforts of the poorer ones into more suitable areas. This is a vital need, and it requires time, effort, and interest on the part of the advisor in order to be effective. All too frequently the undergraduate student is tolerated because he is a means to an end, that, namely, of providing bread and butter for the scholar whose interests are far removed from the student, and it does not take the student long to get the feeling that he is a nuisance instead of a welcomed companion in scholarly work. The misplaced student is quite another problem, however, and good counselling service is at a premium.

3. A broad liberal education is recommended over one of a highly specialized and practical nature. A major field of interest, which will permit the student to come to grips with a subject in a mature and satisfying fashion, is considered to be an integral part of this liberal education, but the program of specialization should not be separated in time from the liberal aspects of the student's intellectual growth. The committee argues, and wisely so, that choice of the major should under no circumstances be dictated, but rather should be determined by the student's interests and the quality of the staff prepared to lead the student to mastery of a particular field. Seminars, research, and thesis preparation are encouraged instead of simply a concentration of courses in an area. The present system of acceptance into medical schools tends to defeat this program. Since the student cannot know until the beginning of his final year which of the 81 accredited schools will consider him just the man they are seeking, he must meet the requirements for a variety of schools having a variety of required courses. The student finds it difficult to anticipate all of the obstacles likely to be thrown in his path, and it is little wonder that at the end of his fourth year he winds up with a program that is a hodge-podge of this and that. His sampling technique is hardly conducive to a directed and integrated intellectual growth. Early acceptance by medical schools, say by the end of the sophomore year, and a reduction in requirements to an absolute and uniform minimum, would give the student the last two years in which, free of anxieties, he could pursue a much more meaningful program of study.

4. A corollary recommendation is that the 4-year undergraduate program is much to be preferred over a 2-year or 3-year preparation. It follows from what has been stated above that the senior year is a culminating one in which reasonable mastery of a particular subject has been achieved at the same time that the liberal aspects of the program have been proceeding apace. A 2-year or 3-year program is to be discouraged. Intellectual maturity can scarcely be achieved in this time, the student could undertake no concentrated study of a field of interest, and only normal course work is possible. The committee is very well aware of the fact that outside the field of the major, the level of course work is all too frequently elementary and lacking in challenge.

5. Courses duplicated in medical schools are not recommended, while those such as psychology and the biological courses emphasizing modern points of view are considered desirable. Stress is given to those courses such as writing and speech which deal with the arts of communication. Anatomy, mammalian physiology, histology, and bacteriology are consequently deemphasized, although the quality of teaching and point of view of the instructor can make all the difference in the world between a static and a dynamic course.

6. Outside activities by students are considered to be as necessary for development as are the more formal aspects of coursework, but that a judicious balance is equally necessary is obvious to everyone except the impressionable undergraduate.

The two remaining recommendations deal with liaison between the colleges and the medical schools, and with the promotion of good teaching. Both are important parts of a coordinated educational program, and both could stand further implementation.

In appraising the book as a whole, it is quite clear that the subcommittee has focussed its attention on a problem that has long needed clarification not only in so far as it concerns the preprofessional education of prospective medical students but also as it concerns the role of the colleges in the liberal training of all professional men. The colleges occupy too important a position in our national structure to be subordinated to the expediency of immediate and utilitarian ends, and while the recommendations made are obvious, in the sense that they revolve around the heart and soul

of a truly liberal education, they are sufficiently worthy to demand continued scrutiny and reemphasis if only to prevent the degradation of the liberal arts program. It is therefore encouraging that in this case the criticisms, both destructive and constructive, come from a professional group farsighted enough to see the whole of education in its proper perspective. It is a book that should be on the desk of anyone who is concerned with the education of the American youth at all of its various levels.

REVIEWS AND BRIEF NOTICES

General Biology: Philosophy and Education 141
Biology: History and Biography 148
The Young Naturalist 150
Ecology and Natural History 151
Evolution 154
Genetics and Cytology 159
General and Systematic Botany 162
Plant Morphology 163
Economic Botany 165
General and Systematic Zoology 167
Economic Zoology 176
Animal Growth and Development 178
Animal Morphology 179
Animal Physiology 180
Animal Nutrition 183
Biophysics and General Physiology 184
Biochemistry 186
Microbiology 190
Health and Disease 193
Psychology and Animal Behavior 196
Human Biology 200
Biometry 201
De Omnibus Rebus et Quibusdam Aliis 204

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

THE MIND AND THE EYE. *A Study of the Biologist's Standpoint.* *By Agnes Arber. Cambridge University Press, New York.* $3.00. xii + 146 pp. 1954.

Miss Arber has long enjoyed an enviable reputation as a plant morphologist. Her last book, *The Natural Philosophy of Plant Form*, indicated that her perception was equally keen and her penetration equally deep when she turned her attention to philosophical thought. The present volume continues this trend, her inquiry now being directed toward a general analysis of the nature of biological research and a consideration of the bases of biological thinking. These two aspects constitute Parts I and II, which together cover some 125 pages.

In Part I, Miss Arber has characterized biological research as consisting of five essential steps, their nature and logical sequence being such that one can readily agree with her classification. Put briefly, they are as follows: (1) the determination and selection of a problem which appears capable of solution; (2) collection and organization of relevant data; (3) the interpretation of the accumulated evidence; (4) further testing of the conclusions drawn; and (5) the communication of these results, thoughts, and hypotheses to the outside world. As the author emphasizes and as every thinking scientist recognizes, these constitute the heart and soul of scientific methodism, and one may well ask why the obvious has been labored. I can only say that a reading of Part I will convince even the most skeptical that Miss Arber has beautifully and succinctly voiced a pattern of scientific procedure which the clear thinker would instinctively follow but which many need to cultivate if their tedious hours in the laboratory are to bear fruit. It is an exposition which will bear rereading many times, and I for one would place these 50 or so pages high on the reading list of any student who contemplates or is beginning a career of research. Even those of us who consider ourselves comfortably settled in a chosen area of scholarship could derive profit and stimulation from the reflective mood engendered by the author's subtle handling of these deceptively simple rules of research. To convey the impression, however, that Miss Arber has only set down a logical mental procedure for the researcher to follow would do her a grave injustice. These pages bear an imprint that is undeniably her own, and that reflects a mature and facile mind, enriched with and varied by scientific and philosophical experience.

While the first part of this volume is concerned with the mental processes involved in the solution of the immediate problem at hand, the latter half deals with a sixth and final step that carries the investigator beyond these limited boundaries. This step, which Agnes Arber calls contemplation and which she considers a culminating and necessary phase, centers around the search for broader contexts into which immediate truths, in so far as they can be comprehended, are to be fitted. It is a step which involves synthesis rather than analysis; which more often than not deals with the abstract rather than with the concrete; which seeks unity and simplicity within diversity and complexity; which stems from an inner urge of man, the microcosm, for integration with the universe, the macrocosm; and which leads in matured minds to an inner calm and, when voiced, to broad and lasting generalizations, but in small minds to frustration or a blind acceptance of platitudes. Whether metaphysical overtones are heard in the "music of the spheres" will, of course, depend upon the individual. The author feels that biological thought has much to offer to this segment of philosophical thought, a contribution which can return in kind "the often unrecognized largesse which it [biology] has received, throughout the ages, from philosophy." In no small measure Miss Arber has repaid her philo-

sophical obligations with the publication of this commendable volume.

C. P. SWANSON

THE ART OF SCIENTIFIC INVESTIGATION.
By W. I. B. Beveridge. W. W. Norton & Company, New York. $3.00. xii + 171 pp. + 4 pl. 1950.

THE PRINCIPLES OF SCIENTIFIC RESEARCH.
By Paul Freedman. Public Affairs Press, Washington. $3.25. 222 pp. 1950.

These two books are designed principally for young men and women just starting out on a career of research. Both are excellent in conveying the philosophy and principles of scientific research. However, it is difficult to understand why books dealing with the principles of scientific research should be needed, since as a rule those for whom they are intended seldom read them, while those who read them are fully steeped in the philosophy. Both of the books are well written. I myself prefer the monograph by Freedman.

DAVID B. TYLER

BIOLOGY *for Pharmaceutical Students and Others. 2nd Edition.*
By S. Mangham and A. R. Hockley. Baillière, Tindall, & Cox, Covent Garden; Williams & Wilkins Company, Baltimore. $6.50. viii + 634 pp.; ill. 1951.

THE PRINCIPLES OF GENERAL BIOLOGY.
By Mary S. Gardiner. The Macmillan Company, New York. $5.25. xvi + 657 pp.; ill. 1952.

FUNDAMENTALS OF BIOLOGY.
Edited by M. J. Harbaugh and A. L. Goodrich; Contributors, P. L. Gainey, M. J. Harbaugh, R. H. Painter, A. L. Goodrich, H. H. Haymaker, and E. J. Wimmer. The Blakiston Company, New York and Toronto. $6.00. x + 611 pp. + 1 pl.; text ill. 1953.

THE BIOTIC WORLD AND MAN.
By Lorus J. Milne and Margery J. Milne. Prentice-Hall, New York. $6.75. xiv + 588 pp. + 232 pl.; text ill. 1952.

THE HUMAN ORGANISM AND THE WORLD OF LIFE. *Revised Edition.*
By Clarence W. Young and G. Ledyard Stebbins; with the editorial assistance of Richard M. Eakin and E. R. Hall; illustrations by Louise Bush. Harper & Bros., New York. $6.00. xiv + 897 pp.; ill. 1951.

MAN AND THE LIVING WORLD. *Second Edition.*
By E. E. Stanford. The Macmillan Company, New York. $5.50. xiv + 863 pp.; ill. 1951.

FOUNDATIONS OF BIOLOGY. *Seventh Edition.*
By Lorande Loss Woodruff and George Alfred Baitsell. The Macmillan Company, New York. $5.50. xiv + 719 pp.; ill. 1951.

GENERAL BIOLOGY. *Third Edition.*
By Perry D. Strausbaugh and Bernal R. Weimer. John Wiley & Sons, New York; Chapman & Hall, London. $6.00. viii + 813 pp. + 20 pl.; text ill. 1952.

GENERAL BIOLOGY. *Fourth Edition.*
By James Watt Mavor. The Macmillan Company, New York. $5.75. xiv + 875 pp.; ill. 1952.

COLLEGE BIOLOGY. *Fourth Edition.*
By Walter H. Wellhouse and George O. Hendrickson. Iowa State College Press, Ames. $4.00. viii + 371 pp.; ill. 1951.

The varied approaches to college courses in general biology are reflected in some of the textbooks which have appeared in recent months. New textbooks in the subject and revisions of older ones appear frequently, and few instructors can hope to examine all of them.

While courses in general chemistry or general physics are taken primarily by students who have an inclination toward science, the general biology course is commonly taken by, and often required of, the "arts" student as well as the beginning biologist. The problem of how "general" a course in general biology should be arises continually, and some institutions have arrived at the somewhat unhappy solution of offering one general biology course for science majors and another, somewhat diluted version, for the non-science majors. The assumption is that any college graduate, in order to have experienced the minima of a general education, should have an appreciation of the living world and man's place therein.

The concept of general biology as comprising "one semester of zoology, one semester of botany" is not as common today as formerly. Such a sequence, which always includes extensive duplication, is giving way to the year-long course which emphasizes the fundamental unity of all living organisms. Such concepts as cellular structure, energy supply and utilization, mitosis and meiosis, development, genetics, and evolution are presented as general features of the entire biotic world, and the course becomes one of principles rather than of a series of type forms illustrating increasing morphological and physiological complexity. The study of the biology of man is receiving more attention in general textbooks, as is indicated in some of the titles.

The shift of emphasis in the introductory courses has been in many cases accompanied by the feeling that the prospective scientist should receive the same broad purview of the field as a future layman, with specialization coming later. In harmony with this trend, classification has been relegated to a relatively insignificant position in some textbooks, so as virtually to eliminate that frame of reference within which an author moves so freely, but which the neophyte finds incomprehensible. In such textbooks, a synopsis of the plant and animal kingdoms has usually been appended, but the conscious avoidance of technical classification in the text itself, and the substitution of more popular

terminology to refer to the various taxa, creates a chasm which only the very able student is able to bridge.

Characteristic of the more traditional presentation is the textbook by Mangham and Hockley. Even though designed for the pharmaceutical student, the text would have general applicability. Major attention is afforded plant anatomy and physiology, possibly because of the book's original purpose, while the treatment of non-vertebrates is limited to several representative forms. The section on vertebrates utilizes the comparative approach, and is quite satisfactory except for any specific consideration of the human being. The embryology of the frog and chick is discussed, and into a single chapter are compressed the main features of "evolution, variation, and heredity;" this arrangement, at best inadequate, completely abnegates the possibility of utilizing these concepts as unifying principles in the text.

The three new textbooks, by Gardiner, Harbaugh and Goodrich, and Milne and Milne, respectively, all adopt an approach which emphasizes the similarities among living organisms rather than their differences. Although possibly their book is the least attractive of the three, Harbaugh and Goodrich have achieved the closest integration of plant and animal forms within a set of principles and concepts. This success may be due to the fact that the book is the result of close cooperation within a committee of six (including the two editors) representing several biological specialties.

Mary Gardiner and the Milnes present their material on double-column pages of large size, and the latter work is especially outstanding from the standpoint of illustration. In addition to the excellent diagrams and line drawings throughout the text, the Milnes have included ten collections of exceptional photographs, making this the best-illustrated text available. The individual chapters are well-conceived and expertly written. The schemes of photosynthesis and polysaccharide relationships are given in terms of the "1951 model," thus avoiding the impression common in beginning textbooks that all is known about these topics. The authors give a great deal of attention to evolution (over eleven per cent of the book), as well as more than adequate coverage of adaptation, ecology, economic biology, and conservation.

Gardiner's book, although using a "principles" approach, gives considerable attention to morphology in one of the four sections of the book, The Organization of Biological Systems. Thus she supplies an excellent basis for the functional considerations taken up in the next section. Although most authors would recognize the necessity for including preliminary information about the physical and chemical basis of the natural world, Gardiner does this in a most pleasing way in the first section of the text. The synopsis of the plant and animal kingdoms suffers from its format, which does not indicate the inclusion of the lower categories of classification within the higher ones; indentation of the lower categories would make the entire chart more meaningful to the beginner. The fourth major section of the book, on the evolution of biological systems, includes but a single chapter; the development of the doctrine of evolution is primarily along historical lines, and although well-written, the section concerning our present level of knowledge is somewhat too brief a summary to be convincing.

The two textbooks which emphasize the biology of man (*Man and the Living World*, and *The Human Organism and the World of Life*) initially appeared between 1938 and 1942, and have now undergone their first revisions. Of these, the Young and Stebbins is the most anthropocentric, with two-thirds of the book devoted primarily to man. Several chapters are devoted to psychology, and such topics as motivation and emotional adjustment are considered as closely integrated aspects of human biology—which they certainly are. While human biology is correlated briefly with that of the lower animals throughout the first section of the text, the remainder of the book deals more fully with the other inhabitants of the biotic world as well as some of the more general aspects of biology. Some new chapters (on diet, conservation, and history and method in biology) have been added, and the text has undergone a general expansion. Chapter summaries and glossaries have been retained, and question lists are provided to aid the student.

About one-quarter of Stanford's text deals specifically with the biology of man, although much of the remainder stresses human interests or concerns. Both the animal and plant kingdoms receive adequate attention, as do the treatments of genetics and evolution. Considerations of the soil, crop plants, and domestic animals supplement the sections on forest resources and conservation. Throughout, the emphasis is upon those aspects of the living world which directly affect the life and well-being of man.

The four remaining books (Mavor, Strausbaugh and Weimer, Wellhouse and Hendrickson, Woodruff and Baitsell) are all "general" biology textbooks in the broader sense of the term. They attempt to give a well-rounded treatment of the entire field, preferring to let man fit into his rightful place in the world of life. While the treatment is frequently along the lines of a "principles" approach, each considers the taxonomic structure to be important, and devotes space to the expository morphological and physiological treatment of the more common plants and animals.

The veteran of this group is Woodruff's *Foundations of Biology*, which has gone through 7 editions since its appearance in 1922, the present one having been prepared by George A. Baitsell, a colleague of the late Professor Woodruff at Yale. The book has undergone some expansion and rearrangement, but retains its essential nature and value. The appendix includes an

extensive bibliography, a glossary, and synopses of the plant and animal kingdoms.

There is much to be said for the compromise effected by Strausbaugh and Weimer. The first half of their book considers the principles of biology as they apply to all living organisms. The remainder of the text presents a thorough survey of the animal and plant kingdoms, concluding with chapters on ecology, the nature and origin of life, and evolution. A series of 20 colored plates enhances the high quality of the text illustrations, and a glossary has been incorporated into the index.

Mavor's *General Biology* employs a somewhat different approach. After introductory material and a consideration of classification, the cell doctrine and protoplasm, two extensive sections deal with the biology of plants and invertebrates; these comprise half the book. Here the "phylogenetic" approach is used to introduce, illustrate, and amplify biological principles at the various levels of organization. Another section, about one-fifth of the book, considers the anatomy and physiology of the vertebrates, as exemplified in the frog and man. The final chapters concern embryology, genetics, and evolution, plus a well-conceived chapter on ecology, in which the biotic interrelationships of two typical ecological communities (a temperate deciduous forest and a fresh-water pond) are described. Topical outlines and question lists conclude each chapter, and the appendix includes the usual synoptic tables of the kingdoms, as well as reference and background material in chemistry and a glossary. The latter is especially commendable, since it lists the more common Greek and Latin roots, and gives the derivation of each technical term defined.

Although explicitly written for the general college student, the textbook written by Wellhouse and Hendrickson is not a "principles" approach, nor is it well-rounded. Animals get fair treatment, but no plants above the thallophytes are considered. The treatment of chordate anatomy and physiology is based upon the frog, and man receives only incidental attention. The treatment of evolution is brief and unsatisfactory, since only the history of animal life on the earth is considered. Since there is an obvious bias in favor of animal life, the advisable thing to do would be to eliminate the remaining botanical material and entitle it outright a textbook of zoology.

It is interesting to note that the conversion to the newer concepts in plant taxonomy has been anything but universal in this group of textbooks. Some authors specifically state that they are retaining the Engler and Prantl classification, while others do so tacitly. The earlier quadri-divisional scheme certainly possesses a practical applicability and teachability that the more phylogenetic natural classification of Tippo lacks.

The instructor of the college general biology course thus has a wide choice of textbooks, with varying emphasis, length, and attention to detail. That the ideal textbook has already been written is an opinion reserved for the textbook authors themselves.

FRANK C. ERK

MAN AND THE BIOLOGICAL WORLD. *Second Edition. By J. Speed Rogers, Theodore H. Hubbell, and C. Francis Byers; with illustrations by William L. Brudon. McGraw-Hill Book Company: New York, Toronto, and London.* $5.75. xiv + 690 pp.; ill. 1952.

Since the major aim of science is "to reduce the apparent complexity of natural phenomena to some simple fundamental ideas and relations" and since efficient management of scientific knowledge depends upon an understanding of existing theories plus an understanding of the interactions between facts and theories, it is reasonable to expect that elementary textbooks of science will give as full an expression to these aspects of science as their subject matter permits. The facts of biology gain their unity, such as exists, from four major theories—the theories of evolution, of the cell, of biogenesis, and of genetics. Since biology in many ways is a very young science, one finds in biology, in addition to theory, many generalizations by simple addition and many miscellaneous collections of facts that are poorly integrated in any manner.

When one examines the textbook by Rogers, Hubbell, and Byers with these things in mind, one finds much to be desired. Most of their failures are shared by nearly all biology textbooks, and consequently the criticisms can be softened by considering the times in which we operate.

Chapter One discusses briefly the four parts into which the book is divided: The Individual Organism; The Continuity of the Race; The Changing Generations: The Evolution of Life in Time and Space; and The Economic and Social Interrelations of Organisms. Also briefly discussed are scientific method and the cell theory.

The discussion of scientific method, while somewhat better than those found in most elementary biology, botany, or zoology textbooks, does not show that the authors have studied this subject sufficiently. If authors insist on discussing scientific method in the first chapter, they would do well to follow Conant's discussion in section three of his Foreword to the Harvard Case Histories. The brief discussion of the cell theory as an example of scientific method is inadequate, and the inadequacies are not sufficiently taken care of in later discussions of the cell or in those places where the cell theory is intertwined with other subjects. Since the cell theory is one of the four major concepts in biology and since it has been used as in example of scientific method, it should have had better treatment. A bit of history, a

description of a generalized cell, a description of some different kinds of cells, and descriptions of mitosis and meiosis, are not sufficient. Had these subjects, however, been used explicitly to illustrate general characteristics of good scientific theory (see Holton, G., *Concepts and Theories in Physical Science*, p. 138 ff.), they might have given method and facts more meaning and have left the student with some view to the future development of this still growing theory.

Chapters 2 to 9 deal with human anatomy and physiology. The two subjects are intertwined in an interesting and efficient way. One feels the strength of the authors here in all subjects except in a few things that are largely biochemical. A simpler terminology for digestive enzymes is now in use by biochemists (see Baldwin, E., *Dynamic Aspects of Biochemistry*, 2nd ed.), and this could well be used in elementary biology textbooks. Chapters 9 to 12 describe in the usual way the structures and functions of the higher plants.

A presentation of "man" in the early chapters of biology books is becoming a habit that should be thoroughly examined. Pedagogic "reasons" determine this order. If efficiency in the presentation of subject matter in the framework of theory were the aim of biology teaching, and it should be, would we choose to put man first? Probably not. We would develop theory and other generalizations first by choosing the most economical pathways. These pathways more often than not lead through the simpler organisms. The statements about man can be equally well applied to the higher plants.

Chapter 13 is a quick survey of different animals and plants to point out "variety of structure versus uniformity of function." It is an interesting and useful chapter. The authors might have generalized more widely the functions of moist membranes in contact with the environment and the surface-volume ratios.

The discussion of the reproduction of animals and plants in chapters 14 to 18 reports these subjects in excellent fashion. Economy was achieved by starting with lower forms and leading through man and the flowering plants. The authors could have used the development of the theory of biogenesis to illustrate scientific method. They did not even name this fundamental concept of biology nor is it in their index!

Heredity is discussed in a traditional and satisfactory way in chapters 18 to 23. It is surprising that blood group inheritance was left out of the chapter on human heredity and is barely mentioned in a later discussion on races.

Since evolution is the most important theory in biology, the space occupied by it in the next 9 chapters is justified, but the reader will probably agree that the repetition of similar types of evidence from different groups of animals is over-extended. Scientific method enters into the discussion in several excellent ways, and it is good to find Occam's razor in an elementary textbook. The great emphasis upon "the fact of evolution" is hardly necessary, any more than one needs to emphasize the fact of the presence of galaxies outside of our own in the study of astronomy. Had the authors developed more adequately an understanding of science in general, they could better treat of fact and theory in this discussion.

The discussions on geology and fossils, and also the chart, lead one to believe that the eras are separated in time by world-wide upheavals. This, the geologists say, is an old concept that is no longer held. Since the great revolutions are dwelt upon (see pp. 391 to 395, 402, 404, 413, 417, 419, and 455), this is a serious error and it is difficult to know why it was so strongly propagated.

The chapter on the evolution of plants is an excellent brief treatment of the subject. A 2-page discussion of the origin of life introduces this chapter. In a discussion of this length Oparin's views should not have been omitted.

In the discussion of prehistoric man alternative hypotheses on the origin of man are discussed. This treatment of subject matter could well have been exploited in dozens of places in the book in order to show one aspect of scientific method at work. Carlson and Johnson in their elementary textbook on human physiology have set a pattern for this type of discussion, and their pattern could well be copied by textbook writers to the advantage of biology.

The chapters on the evolution of animals and on man are of the sort that make the book especially useful for the teacher who may wish to slant his course toward anthropology. This is good because most books do not reach far in this direction.

The 2 chapters on ecology are interesting and cover the subject well. The "energy cycle" is much emphasized. Is it not more reasonable, inasmuch as the authors themselves say that the energy cycle is noncyclic, to talk of the "energy line," in order to avoid confusion with carbon and other cycles? The authors do not give a discussion of the growth curve of individuals or populations. This general, useful concept should not be omitted.

Discussions of the classification of plants and animals are placed in an appendix. This has some good points. It makes for ready reference; it clears the way for a more organized discussion of the major concepts of biology; and it gives greater emphasis to those subjects which are more important in modern biology, but still retains the tool without which modern biology could not well exist.

In general, this book is aimed at the good students, but it fails to meet this general aim by the omission of references, although many books are mentioned in the text. No questions or study helps are included. The illustrations are very good. The photographic reproductions are excellent with only a few exceptions.

RALPH W. LEWIS

SECONDARY SCIENCE EDUCATION.

By Harrington Wells. McGraw-Hill Book Company, New York, Toronto, and London. $4.50. xi + 367 pp.; ill. 1952.

This new textbook is meant for secondary-science teachers-in-training and for in-service teachers who are taking "refresher" courses. It consists of two parts: Theory and Practice; and Resource Aids. Part I includes chapters on The Integrated Science Program, Science and the Scientific Method, General Science, General Biology, Social Biology, Botany, Zoology, Chemistry, Physics, and Evaluation and Diagnosis. Part II lists sources of audio-visual aids, equipment and supplies, useful magazines, pamphlets, posters, etc., and closes with 2 rather extensive bibliographies: one dealing with professional methods, the other with subject content.

The author expects students who use this textbook to have (1) a prerequisite technical training (for biology majors he calls for "a thorough grounding in plant and animal taxonomy, morphology, physiology, ecology, and economics" and for physical science majors, "inorganic and organic chemistry, general physics, historical and physical geology, and meteorology,") and (2) a mature point of view and breadth of concept that come from the study of modern psychology, sociology, economics, history, English, and experience in the applied arts.

Three themes pervade the text: (1) science–social science interdependence, (2) physical science–life science coordination, and (3) community–industry coordination.

The author admits that "general friction and mutual distrust" often exist "between the faculties of our schools of education and the men and women of science." He says the avowed purpose of the professor of science education is to "effect a merger" between the points of view of the two groups. But the author seems to have missed the basic difficulty that makes for this "general friction and mutual distrust." Men and women of science cannot look with complacency at a situation where science teachers all too often enter their careers in secondary schools without the prerequisite technical training they need. For example, certificated biology teachers are often lacking even in skill with the microscope. Why? Because they have had to spend so much of their college time meeting the "education" requirements for certification (50 hours or more in many states) that they simply could not take many courses in science, in addition to required courses such as English or history.

Scientists would agree with the author that mastery of a special field of science does not necessarily make a scientist a good teacher. But scientists would also insist that courses in education cannot make good science teachers of those who lack adequate technical training in science. The current emphasis on education courses to such an extent that, at least in many cases, insufficient time remains to get adequate technical training must continue to be questioned by scientists who are concerned about effective science teaching in secondary schools.

For those teachers-in-training who have had adequate training in science, this text should prove useful. To in-service teachers of science in secondary schools, Part II on Resource Aids should be especially helpful.

ELLA THEA SMITH

SURVEY OF BIOLOGICAL PROGRESS. *Volume II. Editor-in-Chief, George S. Avery, Jr., assisted by 10 Editors, and an Advisory Board of 5. Academic Press, New York.* $7.00. x + 333 pp.; ill. 1952.

The 8 reviews in this volume represent a fair cross-section of recent developments in certain aspects of biology. It is not to be expected that they could survey the whole of biology at one time, but wise planning in subsequent volumes of the series may enable a reader, over the space of some years, to obtain a really good view of biological progress.

The areas covered are as follows: Effects of Radiations on Biological Systems (A. H. Sparrow and B. A. Rubin); Progress in Human Genetics (H. Kalmus); Biological Oceanography (Gordon A. Riley); Morphogenesis in Plants (Erwin Bünning); The Control of Plant Growth by the Use of Special Chemicals, with Particular Emphasis on Plant Hormones (Louis G. Nickell); Histochemistry (Florence Moog); The Fine Structure of Protoplasm (L. H. Bretschneider); and Physiology of Reproduction in Plants (Aubrey W. Naylor).

In certain cases the reviews have suffered because the authors undertook to survey too vast an area, and as a result have skimmed the surface like a dragon-fly, touching it only here and there. Other authors have been somewhat arbitrary about which topics to treat and which to omit. The reader is also tempted to make comparisons with the contributions to the series *Science in Progress*, made up of the Sigma Xi lectures, and on that basis to conclude that not all general scientific articles need be dull or over-technical. Yet notwithstanding its shortcomings, this is a valuable book in a series that in time should supplement the *Biological Reviews* and the *Quarterly Review of Biology* in aiding hard-pressed biologists to broaden their knowledge of the increasingly varied and technical branches of their subject. Most nearly, the present series seems to fill the place in English of such German series as *Fortschritte der Zoologie* and *Ergebnisse der Biologie*. It is especially gratifying, therefore, to see that in this second volume of the *Survey of Biological Progress*, two noted European contributors have been included.

BENTLEY GLASS

MODERNE BIOLOGIE. *Festschrift zum 60. Geburtstag von Hans Nachtsheim.*

Edited by H. Grüneberg and W. Ulrich. F. W. Peters, Berlin. DM. 43.—(cloth); DM. 39.—(paper). 287 pp. + 4 pl.; text ill. 1950.

In addition to a short biography of Nachtsheim and his bibliography, this festschrift includes 18 contributed papers of widely varied nature. Brief accounts of original work include: G. Dahlberg, Thymus und Fettleibigkeit bei Mäusen; G. Geipel, Ein Beitrag zur Frage der Erblichkeit menschlicher Hautleistenmerkmale; R. B. Goldschmidt, A remarkable structure in the ovocytes of a fish; H. Grüneberg, Skeletal Polymorphism in the Mouse; W. Landauer, Genetic and developmental relations of the mutations for polydactylous, duplicate and diplopod toes of fowl; H. Lüers, Über genetische Versuche mit Kontaktinsektiziden an *Drosophila;* C. Steffens, Identifizierung von Kriegsfindelkindern mit Hilfe von erbbiologischen Ähnlichkeitsgutachten; C. Stern and E. R. Sherwood, The migration of testis sheath cells in *Drosophila virilis*. Somewhat longer research papers are those by P. B. Sawin and D. B. Dietz, Morphogenetic studies of the rabbit (15 pp.), and by B. E. Wolf, Über die Entstehung von accessorischen Kernen im Ei von *Phryne fenestralis* (24 pp.). The remaining 8 contributions are essentially review papers, most of them of considerable value and of a type suitable for such a journal as the *Quarterly Review of Biology*. These include: K. Günther, Ökologische und funktionelle Anmerkungen zur Frage des Nahrungserwerbes bei Tiefseefischen, mit einem Exkurs über die ökologischen Zonen und Nischen (39 pp.); K. Günther, Phylogenetik, Teleologie und Freiheit (37 pp.); G. Heberer, Das Präsapiens-Problem (32 pp.); K. Herter, Vom Lernvermögen der Fische (17 pp.); H. Kappert, Botanische Untersuchungen zur Erblichkeit der Polyembryonie (15 pp.); K. Saller, Der Begriff der Anthropologie (10 pp.); W. Ulrich, Begriff und Einteilung der Protozoen (10 pp.); and S. Wright, Population structure as a factor in evolution (14 pp.).

A. S. ROMER

PROBLEMI DI SISTEMATICA BIOLOGICA.

By Sergio Beer and Alfredo Sacchetti. Edizioni Scientifiche Einaudi, Torino. L. 8000. 671 pp. + 17 pl. + 2 folding charts; text ill. 1952.

This extensive discussion of the problems of systematic biology is a contribution written jointly by a biologist and a physical anthropologist. Beer's primary interest is the morphology, systematics, and biology of insects; he has been especially occupied with the study of color-patterns in the butterflies. Sacchetti, who left Italy for the Argentine in 1949, is a physical anthropologist with a particular interest in biometrics. The contents of the volume reflect very distinctly the dual interests of its two authors. It may be a trifle unfair to them both that their book should be evaluated by a reviewer who concentrates in the field of neither. But if there are any problems central to all biology that are of vital and general importance to workers in each of its constituent areas, they are surely those which concern the specification of that primary biological entity, the organism, in its relationship to other organisms.

Approximately the first half of the book is by Beer, and it presents a detailed historical and analytical account of the problems besetting the systematist who labors to derive a natural system of classification in the conviction that such a natural scheme is of fundamental evolutionary significance. The discussion is long and full. While it attempts to treat its subject-matter from varied points of view, it remains intrinsically an exposition of the morphologist's argument. One rubs one's eyes in incredulity, for instance, on finding a sentence which mentions the racial significance of the Rh factor and is immediately followed by an assertion that neither pH nor rH_2 can be considered to represent general taxonomic criteria.

The latter half of the book, which is mainly Sacchetti's, proposes what this author considers a "demogenetic" solution to the problems of relating the organism to its taxonomic level. The validity of his individual mathematical formulations can of course be judged only by the specialized biometrician. The general biologist, at the risk of being classified statistically at the level of the die-hard, may find it difficult to swallow a mathematical generalization, no matter how brilliant, which for instance deprives human femoral torsion of the mechanico-functional significance which a long series of earlier biological studies has attributed to it. The essence of the biometric approach must be that, though it adds a statistical description of known conditions to analyses of them couched in other terms, it supplements these rather than substitutes for them completely.

It is the fault of the world we inhabit rather than of the authors themselves that the writing of this book had to be accomplished in a kind of literary vacuum, but it is nonetheless unfortunate that the non-Italian literature of the war and post-war years has not been adequately covered. A bibliography of almost a thousand titles includes as its latest reference to the investigations of Sewall Wright a work dated 1941; the latest reference to Dobzhansky's is dated 1941, to Goldschmidt's 1940, to Schindewolf's 1937, to Haldane's 1932. While Kenneth Mather's *Biometrical Genetics* (1949) is listed in the bibliography, it receives in the text only one brief footnote reference.

With these reservations, the importance of the present volume is its recognition of the fact that a central problem of systematics may be dealt with statistically; and from this point of view it must be taken seriously. It is a very heavy book.

JANE OPPENHEIMER

TWO ROADS TO TRUTH. *A Basis for Unity under the Great Tradition.*

By Edmund W. Sinnott. The Viking Press, New York. $3.50. xii + 241 pp. 1953.

The conclusions of scientific materialism emphasize the need for reconciling the rational concepts of the sciences with our ancient religious beliefs which developed in a prescientific age; and force us to reexamine our ideals. The author, a distinguished biologist, helps the reader to clear away the venerable rubbish of the past and the bigotries of the present and to discover a common foundation of enlightened belief and faith on which he can build his own philosophy. We are shown how *both* reason and spiritual insight are valid means for reaching the truth; reason and spirit are the pillars that support our Great Tradition. These two roads are not so different after all, but simply two levels of the process by which a living system learns what is around it. We should rejoice in these differences between the disciplines; from tension between them character is born. This is indeed a helpful book.

ROBERT L. PENDLETON

THE WORKS OF GEORGE BERKELEY, BISHOP OF CLOYNE. *Volume Five: Siris; Three Letters to Thomas Prior; A Letter to the Rev. Dr. Hales; Farther Thoughts on Tar-Water; Varia. Volume Six: Passive Obedience; Advice to Tories Who have taken the Oaths; An Essay towards preventing the Ruin of Great Britain; The Querist; A Discourse addressed to Magistrates; Two Letters on the Occasion of the Jacobite Rebellion, 1745; A Word to the Wise; Maxims concerning Patriotism.*

Edited by T. E. Jessop. Thomas Nelson & Sons, London, Edinburgh, Paris, Melbourne, Toronto, and New York. 30s. per vol. (V) xii + 235 pp. (VI) viii + 255 pp. 1953.

Siris and its sequels in Volume Five of Berkeley's *Works* are of some interest to biologists, for they deal with the nature and medicinal virtues of tar-water. Unfortunately, Berkeley's ideas of botany, chemistry, and medicine are not as original as his *New Theory of Vision* or his philosophy; but they present nevertheless an interesting picture of the scientific outlook of the average intelligent man of the 18th century in Great Britain. Pine-tar was evidently one of Nature's remedies, a safe substitute for soap, opium, or mercury, and especially recommended for sedentary scholars. It is also worth seeing how a consideration of the virtues of tar-water could lead the mind to contemplation of the philosophy of Nature, and thence to the dependence of the world on God.

The most interesting thing in Volume Six, a miscellany about current social situations in the early 18th century, is to observe that concern about loyalty oaths is no new thing, and that in those days it was the Tories (!) who were suspected of being subversive.

BENTLEY GLASS

THEORY OF KNOWLEDGE, *Containing the Enquiry Concerning Human Understanding, the Abstract, and Selected Passages from Book I of A Treatise of Human Nature.*

By David Hume. edited by D. C. Yalden-Thomson. Thomas Nelson & Sons, Edinburgh. 7s. 6d. xxviii + 265 pp. 1951.

THEORY OF POLITICS, *Containing A Treatise of Human Nature, Book III, Parts I and II, and thirteen of the Essays, Moral, Political and Literary.*

By David Hume; edited by Frederick Watkins. Thomas Nelson and Sons, Edinburgh. 7s. 6d. xxx + 246 pp. 1951.

SCIENTIFIC TERMINOLOGY.

By John N. Hough. Rinehart & Company, New York. $3.50. xiii + 231 pp. 1953.

Those who consider words to be something more than just utilitarian symbols without meaning except for their immediate applicability will find the present volume not only useful but equally fascinating. The author's familiarity and feeling for biological and medical terminology, despite the fact that he himself is principally a classicist, further enhances the value of the text to those in the biological sciences who are concerned with the coining of new words, with the suitability of existing words, and with conveying a meaningful and potentially rich language to both professional and non-professional students. Hough approaches his task of discussing scientific words by considering the Greek and Latin alphabets; the roots, stems, prefixes, suffixes, and combining forms of English words; Latin forms and grammar in nomenclature; and then he lists, together with their meanings, terms common in general science as well as those peculiar to medicine, bacteriology, pharmacology, biology, and the Linnaean system. The subject of this volume may, at first sight, seem dry and desiccated, but the author's handling of the material has been light, alive, and pertinent.

C. P. SWANSON

BIOLOGY: HISTORY AND BIOGRAPHY

A SOURCE BOOK IN ANIMAL BIOLOGY.

By Thomas S. Hall. McGraw-Hill Book Co., New York, Toronto, and London. $10.00. xvi + 716 pp., ill. 1951.

Such a collection of zoological source materials, all

translated into English, has long been needed, and this comprehensive collection of 119 pieces will assuredly delight all biologists who feel that a command of their science requires more than a knowledge of the currently accepted facts and the latest theories. Science is a human enterprise; and the history of scientific successes and failures, and in particular the history of scientific concepts, is surely essential to a proper understanding of science. This source book is arranged to relate to certain great biological fields or concepts: the Organization of Animal Life; The Activities of the Animal Organism; The Basis of Animal Behavior; The Origin and Development of the Individual; Cellular Biology; Pathology; Evolution and Heredity; and Zoogeography. The period covered extends from Leonardo da Vinci to the turn of the present century. An impressive array of great zoologists is included, although probably everyone will think of some omission he will deplore. That is inevitable, even in a collection so big as this one.

Two of three more serious criticisms may be made, in a constructive rather than a carping spirit. First, a minor matter, but one that causes the user of the book great annoyance: the names of the zoologists represented have been omitted from the Table of Contents, so that it is not easy at a glance to see who wrote what, or where to look for it. To be sure, there is an index; but it provides no quick correlation between person and principle. Perhaps at slight cost this defect can be remedied in the next printing. Secondly, on no occasion has the essential unity of biology and the artificiality of the separation of zoology and botany been more clearly demonstrated than here, by the effort to separate them. Had the source book been arranged by animal types, the defect would not have been so apparent. But to attempt to deal with Cellular Biology strictly from the zoological side quickly reveals the hopeless absurdity of it: Schwann without Schleiden, Van Beneden without Strasburger, and the like. The same is apparent in the section on Heredity, where Darwin's pangenes and Galton's regressions must do service for Mendelian factors. It would seem to be a better solution of the problem, keeping in mind the necessary limitations in size of any such source book, to have restricted the *Source Book in Animal Biology* to those aspects that are strictly zoological in nature, and to have prepared another source book, one in *biology*, for the great general concepts that unify all life.

This brings me to a final matter. Without disparaging the usefulness of this type of source book, it is fair to point out that this is not the most effective way to deal with the development of any concept of central biological importance. This is not so much because the present selections include topics that develop several threads of thought within each of the broad areas of subject-matter organization—although that is true—but in particular because oftentimes vital steps in the development of a concept have been provided by other biologists who must be excluded for lack of space unless the development of one particular concept is the editor's primary purpose. Thus, while we acclaim the present volume, let no one think the definitive task has been accomplished. The *Source Book in Animal Biology* suffers from the defects of all anthologies.

BENTLEY GLASS

CARL LINNAEUS.

By Knut Hagberg; translated from the Swedish by Alan Blair. E. P. Dutton & Company, New York. $4.50. 164 pp. + 5 pl.; text ill. 1953.

Carl von Linné was one of the great men of his time as well as Sweden's most illustrious son. Prolific writer, royal physician, scientific arbiter, and innovator, teacher, and philosopher: he was all these, and his biographer has attempted to place him properly as a product of his own time while at the same time he considers him as a part of the over-all biological picture. In none of these comparisons does Linnaeus suffer, for he was a man of prodigious talent and energy and possessed of a facile pen, which accounts for the fact that much of what he had to say still remains with us in the form of letters or volumes.

Linnaeus had two beliefs which dominated his thinking: one, that there was design and order in the organisms which grew on earth (Special Creation); the other, that it was his mission to classify these organisms. He did not deviate from the second belief, although the first was shaken though not discarded by his growing knowledge of hybrids. He considered these to be abnormal forms derived from normal species, but he could not come to the belief that they would remain other than abnormal.

The author makes every attempt to depict Linnaeus the man as well as Linnaeus the scientist. Emotionally intense and sometimes unstable, he could be both generous and decidedly arbitrary, vain as well as humble, a detractor as well as a praiser of others. That he was not without humor is indicated by the description of the twinflower which he named after himself. He speaks of *Linnaea borealis* as "a plant of Lappland, of short growth, insignificant, overlooked, flowering only a short time; the plant is called after Linnaeus, who resembles it." The biography, consequently, is much more than a mere recitation of the accomplishments of this man who created the binomial system of nomenclature. It is also an imaginative description of the scientific atmosphere of the time, and to some extent of the social, religious, and political forces which had an impact on Linnaeus. It can be truly said that his own impact on things around him was probably greater than those which influenced him, for he allowed few things or events to divert him from his chosen work.

C. P. SWANSON

GENESIS AND GEOLOGY. *A Study in the Relations of Scientific Thought, Natural Theology, and Social Opinion in Great Britain, 1790–1850.*

By Charles Coulston Gillispie. Harvard University Press, Cambridge. $4.50. xiii + 318 pp. 1951.

All students of the history of the theory of evolution will be profoundly grateful for this thorough, scholarly study by a historian of a topic beautifully characterized by the book's subtitle. The story begins with the controversy, now virtually forgotten, between the "Neptunist" followers of Werner and the "Vulcanist" followers of Hutton. Gillispie traces not only the origins of uniformitarianism in geology, but also clearly reveals how deeply the mind of the 19th century scientist was wrenched between the desire, on the one hand, to see Providence in the design and order of natural law, and at the same time the fear that each extension of natural law would diminish the sphere of activity that required God's constant intervention and management of his creation. Through Kirwan, Buckland, and Sedgwick, to the revolution of thought wrought by Lyell, moves the same guiding theme. Particularly fine is the treatment of Robert Chambers and the *Vestiges of Creation*. The chapter, How Useful Is Thy Dwelling Place, traces to two motives the growth of the movement to provide popular education in scientific subjects for the lower economic classes: not only was it hoped that the understanding and pursuit of science would occupy the time and elevate the minds of the working people, but also that it would, by demonstrating the wisdom of Providence, tend to make them realize the will of God in the existing order, and thus prevent social unrest. "They [the opponents of naturalistic theories of progression] felt two things: that the stability of society not only depended upon but was justified by, the direct and immediate attention of a Providence whose arrangements could be empirically demonstrated in the physical universe; and that its stability depended also upon a general conviction that this was the case."

Never has there been a more convincing demonstration of the conditioning of scientific beliefs by prevailing social and religious opinion; and, that being so, never a more convincing demonstration of the profound importance to scientists of any time or climate of opinion of a study of the history of science that reveals to what extent every scientist is a creature of his social milieu. To recognize this conditioning is the first step toward real intellectual freedom, the first unveiling of the clouded vision.

BENTLEY GLASS

PASTEUR'S AND TYNDALL'S STUDY OF SPONTANEOUS GENERATION. *Case 7.*

Edited by James Bryant Conant; Associate Editor, Leonard K. Nash. Harvard University Press, Cambridge. $1.25 (paper). 61 pp.; ill. 1953.

Like the previous Harvard Case Histories, Case 7 aims to help college students majoring in the humanities or social sciences to recapture the experience of those who once took part in a "revolutionary advance in science." That Pasteur's and Tyndall's experiments dealing with spontaneous generation were major contributions to a "revolutionary advance in science" is amply shown in this highly readable Case 7.

This Case History contains a foreword, a general introduction, and translations of portions of Pasteur's "Memoir on the Organized Corpuscles which Exist in the Atmosphere," a translation of excerpts from Redi's "Experiments on the Generation of Insects," and Tyndall's article on spontaneous generation.

Any college student and many students in high-school science will gain real insight into scientific methods from this and the other Case Histories.

ELLA THEA SMITH

SCIENCE AND TECHNOLOGY IN PROVIDENCE, 1760–1914. *An Essay in the History of Brown University in the Metropolitan Community.*

By Donald Fleming. Brown University, Providence. $1.25 (paper). 54 pp.; ill. 1952.

THE YOUNG NATURALIST

CURIOUS CREATURES.

Written and illustrated by Erna Pinner. Philosophical Library, New York. $4.75. 256 pp.; ill. 1953.

Among the creatures of the earth there are those whose structures and habits are sufficiently bizarre to strain the imagination. How these attributes came into being, what were the transitional forms from which they arose, and, evolutionarily speaking, what survival value they might have, remain unanswered in many instances, and our present theories of evolution often seem inadequate to account for them. The author, however, is not concerned with the speculative aspects of origin, but seeks simply to describe the many forms which, as she states it, indicate "Nature's love of play and design." This is not a profound book; yet on the other hand, it is not uninteresting. In popular fashion, the author ranges the world in search of the curious, grouping these into various categories such as feeding habits, flight structures, or camouflage. The descriptions are well turned, with no overt attempt to amaze the reader any more than these creatures by themselves are apt to do, and the black-and-white pen drawings assist nicely in complementing the text. The young naturalist should find this a particularly intriguing volume.

C. P. SWANSON

HAPPY ANIMAL FAMILIES.

Pictures by John Pike; poems by Ernestine Beyer. Grosset & Dunlap, New York. $1.00. 26 pp.; ill. 1952.

This is a delightful picture-book of verse about animal families for children 2 years old and up. The artwork is excellent, particularly the striking portrayals of young animals, wide-eyed, snub-nosed, and mischievous. The pictures and verse are educational as much as they are entertaining.

ELIOT STELLAR

BUILDING HEALTH.

By Dorothea M. Williams; drawings from the studio of Waneeta Stevic, Univ. of Colorado School of Medicine. J. B. Lippincott Company, Chicago, Philadelphia, and New York. $3.20. xi + 431 pp.; ill. 1952.

This textbook for health instruction in the junior high school contains 19 chapters in 4 units: What does growing up mean to you? How can you help your body in its work? How can you make the most of yourself? How can you act your age? Each chapter is preceded by a 2-page spread of pictures called a Picture Preview. There are also photographs in the text, and a few drawings and diagrams. Each chapter is followed by review work, with questions for self-testing, a list of books and a list of films, and suggestions for activities relating to the subject of the chapter.

HARRIETTE D. VERA

ENJOYING HEALTH.

By Evelyn G. Jones; drawings from the studio of Waneeta Stevic, Univ. of Colorado School of Medicine. J. B. Lippincott Company, Chicago, Philadelphia, and New York. $3.40. xi + 434 pp.; ill. 1952.

This textbook for health instruction in the high school has 23 chapters grouped into 5 units: How can I become the person I want to be? How can I keep in good condition? How can I improve my appearance? How can I be a worth-while and likable person? What helps do I have in keeping well?

The format is similar to that of *Building Health*, written for junior high school students. Each chapter has a 2-page picture preview, and is followed by a test and lists of books and films. At the end of the book are references, film sources, a glossary, and an index.

According to the Preface, the book was written to change health habits and attitudes, and is based on the Denver study of health interests of children. The approach seems to be intended for high school students as "children," rather than as young men and women about to assume responsibilities as adults. There is much emphasis on "I" in this book; a very personal attitude is taken to the reader as an individual rather than as a member of a group or citizen of a community.

HARRIETTE D. VERA

ECOLOGY AND NATURAL HISTORY

FUNDAMENTALS OF ECOLOGY.

By Eugene P. Odum. W. B. Saunders Company, Philadelphia and London. $6.50. xii + 384 pp.; ill. 1953.

This book was written primarily as a textbook for college courses in ecology, and as such it is a very successful venture. The emphasis is on animal ecology. Most of the book (the first 200 pages) gives an outline of Basic Ecological Principles and Concepts. The next 100 pages is a compressed account of the ecology of freshwater, marine, and terrestrial communities. A final briefer section is called Applied Ecology.

The "principles and concepts" section begins with the broad and difficult concepts of the ecosystem, niche, and biogeochemical cycles. It then narrows down to a discussion of limiting factors of the environment, the food chain, and productivity. We are next introduced to the population ecology of single species, then interactions between species, and full circle back again to the community, but this time to study succession, stratification, and periodicity. The sequence from general to particular and back again to general is also followed out in particular sections. Here the topics are introduced by a generalization, after which follow examples. As a teaching principle I myself prefer the reverse procedure, especially in ecology, where rigor and precision of statement are so often lacking. Nevertheless, Odum is successful in making most of his points with directness and clarity and with a selection of good examples. Ecologists will be relieved to discover that this is an eminently readable book despite the formidable and wordy headings of some of the chapters (e.g., Principles and Concepts Pertaining to Organisation at the Interspecies Population Level).

With certain notable exceptions (e.g., Table 10), the student will need to master fewer useless terms than he is confronted with in many modern texts on ecology; but Odum by no means reaches the irreducible minimum. Some new terms are added. The coining of "density-proportional" to make a sacred trio with "density-dependent" and "density-independent" only serves to confuse an already confusing doctrine in animal ecology. The quantitative aspects of ecology are emphasized, and this is good. But the desirability of introducing theoretical equations of population ecology into an elementary text might well be questioned. They are necessarily simplified to such an extent as to be either incomprehensible (p. 123) or both incomprehensible and misleading (p. 167) to the beginning student. Insufficient distinction is made between the theoretical model

which the equation represents and the situation in nature from which it is far removed. The same criticism might be made of the brief treatment of experimental models of the so-called "Gause rule" and its extension to "competition" in nature. These are all subtle problems which are difficult to deal with in an elementary text without giving the impression that their solution is simpler than is in fact the case.

The section of the book on Habitats is a useful adjunct to the sort of field work which is done in courses in ecology and field zoology in the United States. This is particularly so for the part on freshwater ecology. As a whole, the major division of the book into the "principles approach" and the "habitat approach" tends to show how different these two approaches are to the study of ecology. The student may wonder, as others of us have, what connection there is between them. The major omission of the book is any treatment of the relation of ecology, genetics, speciation, and evolution.

On the whole this book can be warmly commended to college students as one of the best modern texts on ecology.

L. C. BIRCH

THE NATURAL HISTORY OF MAMMALS.

By François Bourlière; translated from the French by H. M. Parshley. Alfred A. Knopf, New York. $5.00. xxii + 362 + xi pp. + 14 pl.; text ill. 1954.

The English version of this book retains all of the freshness and vigor of the French original. While M. Bourlière modestly points out that the book is really only a beginning, intended mainly to stimulate further research into mammalian behavior, the reader will be amazed at the knowledge which he has organized and presented in such a fascinating style. Far from being provincial, he has drawn his examples from the scientific writings of the world at large, and has shown a breadth of knowledge and experience achieved by few.

All aspects of mammalian behavior are given their share of attention, with numerous select photographs and drawings illustrating the subject matter. The material is treated in such a way that one learns not just facts about certain mammals, but about differences and similarities throughout the entire class: how mammals are adapted to perform certain functions; and how different kinds of mammals achieve the same ends in different ways. The final chapter on the structure and dynamics of natural populations is especially fine, summarizing the work of many research scientists and organizing their findings in a form understandable to any intelligent reader.

The inclusion of a list of general and special references gives further sources of information on all phases of mammal life. The list is divided by subjects, so that anyone interested either in a particular group of mammals, a particular geographic area, or a particular phase of mammalian behavior is equally well served.

The publishers are to be congratulated on the attractive preparation of this book, which is a classic of its kind. I venture to predict that it will eventually become a collector's item. Certainly it deserves a place on the shelf of every naturalist, amateur or professional.

BRYAN P. GLASS

A HERD OF MULE DEER. *A Record of Observations Made on the Hastings Natural History Reservation.*

By Jean M. Linsdale and P. Quentin Tomich. University of California Press, Berkeley and Los Angeles. $8.50. xiii + 567 pp.; ill. 1953.

The Hastings Reservation of the University of California is the home of a sedentary herd of mule deer whose daily and seasonal activities the authors have kept under close scrutiny for a period of three years. A glance through the index of the book is sufficient evidence of prolonged and painstaking observations. Under the headings of Structure, Communication, Mannerisms, Relations to Other Animals, Habitat, Activity, Food, and Reproduction, the routine behavior of these animals has been recorded and set down with a remarkable amount of detail. Being a nonmigratory population, the animals have been under surveillance during the entire annual cycle.

Under various major headings in each chapter the authors have summarized their findings. Usually, however, this is followed by pages of data, apparently taken directly from field notes, without synthesis, except that the notes have been sorted out and included in the most appropriate part of the text. Such minutiae as the exact number of chews counted in 7 separate instances of cud chewing, the angle at which the tail was held in 13 observed cases of defecation, and many similar examples, are certainly strong proof in support of the authors' general statements, and are just as surely dull reading except to the most avid student of deer behavior.

On the other hand, the section on deer foods is so organized that anyone can understand the variation in the palatability, use, and nutritional value of the native flora. Also, the discussion of change in structure of antlers and of dental changes from youth to senescence is invaluable.

In brief, here is a book which presents in vast detail the daily life of the mule deer. If the data had been as painstakingly digested as they were accumulated, the text would be much more readable.

BRYAN P. GLASS

THE UNDERSEA ADVENTURE.

By Philippe Diolé. Julian Messner, New York. $4.50. xiii + 236 pp. + 24 pl. 1953.

Invention of the aqualung has opened up one of the relatively few remaining unexplored regions of the earth, in this case the coastal waters of temperate and tropical shores. The aqualung has freed the diver from the cumbersome equipment of the past, greatly extended his activities, and, if one can accept the many recent writings on the subject, has opened up a completely new and fascinating world. These undersea excursions seem to take on an aspect which can be compared only to the passion which possesses and spurs on mountain climbers and cave explorers.

The present volume well describes the fascination that the underwater world holds for some people. There is a tendency on the author's part to overdramatize the sea and its inhabitants, and to humanize many of the marine animals encountered. It is rather difficult, for instance, to consider the octopus to be "an intelligent domestic and perhaps emotional animal," at the same time that it is quite obvious that many other descriptions of marine life are those of an enthusiastic but untrained reporter rather than those of a scientifically schooled observer. On the other hand, the author is sufficiently well versed in marine biology to recognize that there are many problems of an ecological nature which remain to be solved. The book, in addition, is also a plea for an immediate utilization of the resources of the sea. The areas described are along the French coast, and it is the author's contention that the sea is practically unexploited, yet ready to be utilized in a wide variety of ways. It may well be, as the author predicts, that man's greatest benefits are still to be derived from the vast and not quite so inscrutable sea.

C. P. SWANSON

ENDOSYMBIOSE DER TIERE MIT PFLANZLICHEN MIKROORGANISMEN.

By Paul Buchner. Verlag Birkhäuser, Basel. S. fr. 66.50 (cloth); S. fr. 62.40 (paper). 771 pp. + 3 pl.; text ill. 1953.

This indispensable revision succeeds the versions issued in 1921 and 1930. It will surely preserve its long-held status as the definitive review of its field and as an inspiration for the languishing craft of comprehensive monography.

The present edition is slightly shorter than the second, owing largely to the contracted treatment of algal symbioses in accordance with the virtual neglect of this field in the interval. The text is thus most fully concerned with the symbioses of intracellular microorganisms in insects. This topic has hitherto been the subject almost exclusively of descriptive, morphological research, but the fragments of experimental studies on the physiology of the symbionts and mutual relationships with the host are extensively discussed. More recently, many geneticists have awakened to the pertinence of the many symbioses that are perpetuated in heredity and, conversely, have made their own contributions to the study of symbiosis (e.g., L'Heritier on sigma-*Drosophila;* Sonneborn on kappa-*Paramecium*); but these aspects are not included here.

Despite the documentation of Buchner's reviews, some workers have nurtured the skeptical inference that the symbionts are merely specialized mitochondria (which recalls the now discredited theory that mitochondria are microbial inclusions readily cultivable in vitro). If nothing else, the numerous insects that have been artificially cured of their symbionts should smother such doubts—except that we cannot ignore the startling and uncomfortable fact that green plants can be "cured" just as readily of their chloroplasts by chemotherapy. The most conspicuous failing in this phase of entomological research has been the lack of a microbiological orientation and close heed to "Koch's Postulates," which apply no less to symbiosis research than to its subsidiary field of infectious disease. Presumably for technical reasons, the microsymbionts of the most intimate complexes have not been grown in vitro, but it would be more accurate to insist that no convincing evidence has usually been brought forward that the isolated microbes are inherent to the symbiosis. The potential usefulness of the aposymbiotic insect as a specific criterion for such claims, as well as for the general application of the symbiosis concept, by virtue of reinfection experiments, has not been adequately emphasized, though reinfections and cross-infections have been recorded for a few insects whose symbionts are readily cultivated (*Rhodnius prolixii; Lasioderma sericorne*). Cultivation of the symbionts in vitro would not be obligatory in the first instance, and the reinfection test should thus guide the development of the technique for their identification, maintenance, and finally artificial cultivation. The outcome of this controversy I would predict is not an unmitigated defeat of the mitochondrial at the hands of the microbial theory for chloroplasts and insect symbionts but rather a reconciliation in terms of a unifying concept labelled elsewhere as the plasmid.

A work of such profound merit and diligent detail warrants translation to accommodate students for whom German is not a native tongue. The content, and perhaps the style, of this monograph are too formidable for casual perusal by the English-speaking student. A translation would enrich the teaching of biology and stimulate research in symbiosis more than enough to justify the task. But whatever the language, no serious student of biology can afford to miss an acquaintanceship with this work.

J. LEDERBERG

THE BLACK RIVER STUDIES. *The University of Missouri Studies, Vol. XXVI, No. 2.*

By John L. Funk, Edward M. Lowry, Mercer H.

Patriarche, Robert G. Martin, Robert S. Campbell, and Timothy R. O'Connell, Jr. The University of Missouri, Columbia. $2.50 (paper). 136 pp. + 2 pl.; text ill. 1953.

This is a series of papers on the status of the Black River before and immediately after its impoundment by Clearwater Dam in 1947. There are seven papers which deal with the character of the basin, the benthos of the stream, the fishes and their management. Further papers dealing with the effects of the impoundment are to be published at a later date, and the whole series is intended to be a guide to management policies for future impoundments in the Ozarks. The example set by this publication is one that should be followed in other regions of the country, since it appears that there is to be no end to the building of dams, and it is often difficult to assemble the scattered literature relating to a given river system since the invention of that prolific monster, the mimeograph machine.

JOEL W. HEDGPETH

MUSEUM PICTORIAL. *Number 1.*

Denver Museum of Natural History, Denver. 56 cents (paper). 64 pp.; ill. 1951.

Museum Pictorial is to be a periodical printed by offset, issued irregularly—but about four times a year—and richly illustrated with photogravure reproductions of fine photographs from the archives of natural history museums. The first issue is devoted entirely to a single article, Nature Photography with Miniature Cameras, by Alfred M. Bailey of the Museum's staff, who is also one of the six members of the Editorial Committee charged with the publication of *Museum Pictorial*. The photographs are indeed superb, and further issues will unquestionably be awaited eagerly by children and adults alike. More publications of this sort by museums would help tremendously to enliven biology teaching and instil a love of plants and animals into prospective scientists and amateur naturalists.

BENTLEY GLASS

THE BIOLOGY OF THE DOVER SOLE, MICROSTOMUS PACIFICUS (LOCKINGTON). *Fish Bulletin No. 85.*

By Frederick B. Hagerman. State of California, Dept. of Fish and Game, Bureau of Marine Fisheries. Free (paper). 52 pp.; ill. 1952.

A CENSUS OF THE GANNET (SULA SERRATOR) IN NEW ZEALAND. *Notornis, Vol. 5, No. 2, October, 1952.*

By C. A. Fleming and K. A. Wodzicki. Paper. Pp. 39–78 + 32 pl.; text ill. 1952.

EVOLUTION

TRAITÉ DE PALÉONTOLOGIE. *Tome I. Les Stades Inférieurs d'Organisation du Règne Animal. Introduction. Généralités. Protistes. Spongiaires. Coelentérés. Bryozoaires.*

Published under the direction of Jean Piveteau. Masson et Cie., Paris. 8,900 fr. (cloth); 8,300 fr. (paper). 782 pp. + 10 pl.; text ill. 1952.

TRAITÉ DE PALÉONTOLOGIE. *Tome II. Problèmes d'Adaptation et de Phylogénèse. Brachiopodes. Chétognathes. Annélides. Géphyriens. Mollusques.*

Published under the direction of Jean Piveteau. Masson et Cie., Paris. 9,700 fr. (cloth); 9,000 fr. (paper). 790 pp. + 24 pl.; text ill. 1952.

TRAITÉ DE PALÉONTOLOGIE. *Tome III. Les Formes Ultimes d'Invertébrés: Morphologie et Évolution. Onychophores. Arthropodes. Échinodermes. Stomocordés.*

Published under the direction of Jean Piveteau. Masson et Cie., Paris. 10,320 fr. (cloth). 9,600 fr. (paper); vi + 1063 pp.; ill. 1953.

The last comprehensive handbook of paleontology was written by K. A. von Zittel. Its paleozoological part consisted of 4 volumes, published in Germany during the years 1876–93. Since that time paleontology has immensely increased in new facts and aspects, so that another critical synopsis became more and more urgent. In 1930 O. H. Schindewolf started the organization of a new handbook, which was planned to comprise 20 volumes and to be written by a great number of specialists all over the world. Unfortunately, no more than 9 issues could be published in the years 1938–1944; then the handbook became a victim of the war. But the idea survived and was resurrected by two other editors in two different countries. In France, J. Piveteau has succeeded in preparing a *Traité de Paléontologie*, which in 7 volumes is to cover the invertebrates as well as the vertebrates. About the same time, R. C. Moore in the United States prepared the *Treatise on Invertebrate Paleontology*, the first issue of which has just come out. Similar to the *Traité*, it aims to present the invertebrates in 3 volumes.

While Zittel in his time, as a single author, still could master the whole field of paleozoology, the task now has to be distributed among a great number of specialists. The uniformity of Zittel's handbook will thus never be reached again. In the *Traité* it seems even especially difficult to obtain a full equivalence of the different chapters, since for all of them no adequate French-speaking specialists are available. Thus it happens that many parts are excellent, while others seem to be less satisfactory. Yet, seen as a whole, the *Traité* is a very valuable work, indispensable for every one concerned with paleontology, not only for the paleontologist himself, but also for the geologist and the biologist. Here, of course, it is impossible to give a detailed and critical review of all the different contributions. Many of them are not free of mistakes; every specialist will be able to note them in a greater or smaller number within his special field. That seems inevitable in so comprehensive a work and should not be condemned too much. Three

volumes have been published up till now. We must restrict ourselves to a general survey of their contents.

Vol. I. The Introduction, written by the editor, J. Piveteau, gives a historical sketch of paleontological science with special reference to French authors. The second chapter, on fossilization, tracks, and trails, is by J. Roger. H. Tintant is the author of an excellent survey of the principles of taxonomy, in which he rejects the tendency toward the exaggerated splitting of genera and species so widespread among paleontologists. C. Dechaseaux reports on the chronology and ecology of fossil animals. L. Cuénot and A. Tétry discuss the phylogenetic relations of the animal kingdom and illustrate them by a somewhat unusual genealogical tree.

These introductory parts are followed by the systematic treatment of the different stems. They each begin with a morphological introduction, include a more or less complete description of orders, families, and genera, and conclude with general remarks concerning phylogeny and ecology. The character and the extent of the single chapters in this and the other volumes are very diverse. Some hardly surpass the scope of a good textbook, while others nearly attain completeness. The genera partly have and partly lack definition, with or without naming the genotypes. A great number of figures, more than a thousand in this volume, serves to illustrate the text. They are mostly well chosen, although others are less satisfactory.

The Foraminifera have been treated by J. Sigal, all the other protistids by G. Deflandre. The latter portions are especially rich in new information, since they contain many of the personal results of the author. The Porifera ("Spongiaires") are reviewed briefly by L. Moret. The Coelenterata have been exhaustively elaborated by J. Alloiteau and M. Lecompte. Several new superfamilies, families, subfamilies, and genera are introduced by these two authors. The volume concludes with an article by E. Buge on the Bryozoa, which are united with the Brachiopoda and Chaetognatha to a group of "Vermidiens." It is somewhat surprising that these "Vermidiens" precede the Annelida, which follow in the second volume. But this arrangement corresponds to that given by Cuénot in his genealogical tree.

Vol. II. The second volume bears the general title "Problèmes d'adaptation et de phylogenèse," but a special treatment of these topics to justify the heading is missing. The Brachiopoda, Chaetognatha, and Annelida have been ably treated by J. Roger. The Conodontophorida are inserted in the Polychaeta, but with full emphasis on the problems of their taxonomic position. The Mollusca are distributed among the following authors: E. Basse, C. Dechaseaux, G. Delépine, G. Lucas, J. Roger, G. and H. Termier. All their articles are very extensive and well illustrated. That on the ammonites contains 24 phototypic plates with figures taken from Roman's well-known work.

Vol. III. The third volume covers the rest of the invertebrates, mainly the Arthropoda, Echinodermata, and Stomochordata. A distinction between Protostomia and Deuterostomia has not been made. The first chapter, written by C. Dechaseaux, deals with the Onychophora. In the presentation of the Arthropoda the following contributors take part: C. Dechaseaux, N. Grekoff, P. Hupé (his article on the trilobites is the most voluminous and exhaustive one), D. Laurentiaux, J. Roger, H. and G. Termier, and G. Waterlot. In the same manner the Echinodermata are distributed among a large number of authors: F.-M. Bergounioux, L. Cuénot, M. Deflandre-Rigaud, J. Piveteau, H. and G. Termier, and G. Ubaghs. The Stomochordata are introduced by C. Dechaseaux, the Pterobranchia and Graptolithina are described by G. Waterlot. A last chapter by H. and G. Termier deals with the groups of uncertain affinities: the Machaeridia, Conularida, Hyolithida, and Tentaculitida. The enumeration of these names shows that some authors have had to master quite a lot of very different groups.

This volume is the most voluminous of the three, which exhibit a steady increase in the number of pages as well as the price. It is to be hoped that there will be no further progression in the 4 following volumes, which are to deal with the vertebrates. They will be awaited with great eagerness.

O. H. SCHINDEWOLF

AN INTRODUCTION TO HISTORICAL GEOLOGY *With Special Reference to North America. Sixth Edition. By William J. Miller. D. Van Nostrand Company, New York, Toronto, and London.* $5.50. xi + 555 pp.; ill. 1952.

The first edition of this book appeared in 1916. Since that time 5 new editions and 16 reprintings have been published. That seems to speak for the quality and fitness of this elementary "Introduction," which represents in a manner conventional throughout what is to be expected from such a textbook. The new edition has been revised, but without changing the basic character of the work. There are introductory chapters on Geologic Time, Fossils, Organic Evolution, Rock Formations, The Earth's Interior, etc. The main part is devoted to a detailed description of the different periods, with intercalated chapters summarizing the Paleozoic, Mesozoic, and Cenozoic Life, respectively. An appendix gives a survey on the classification of plants and animals which seems all too short to be effective. Many new figures have been added and some of the illustrations in the former editions have been replaced by new ones. But in this respect more could have been done, for many of the figures, especially those of fossils, are poor and out of date.

O. H. SCHINDEWOLF

LEHRBUCH DER PALÄOZOOLOGIE.

By Oskar Kuhn. E. Schweizerbart'sche Verlagsbuchhandlung (Erwin Nägele), Stuttgart. DM. 30.—(cloth); DM. 28.—(paper). vi + 326 pp.; ill. 1949.

As the author notes in his introduction, a modern text of paleozoology in German was badly needed. Except for one brief account, no work of this sort has appeared for more than a quarter century, and in consequence no text available to the German beginner could introduce him to the altered concepts brought about in many fields of paleontology through modern work. Kuhn's volume goes far toward filling this void. About two-thirds of the text is devoted to the invertebrate phyla, a third to the vertebrates. The illustrations, 244 in number, are adequate for a book of elementary nature.

As to style of presentation, the author had a choice of models. The old Stromer text was a readable account of the various animal groups, which did not neglect the morphological data necessary for diagnosis, but in addition gave a general picture of the habitus and relationships of the forms concerned; on the other hand, the classic Zittel text (in two large volumes) was essentially a reference Handbuch, with diagnoses of groups large and small but with little concern for phylogeny, life habits, or function. Kuhn has deliberately patterned his volume after the Zittel work, a course which seems to me to be a mistake for an elementary textbook. It is essentially a continuous series of group definitions. Unless accompanied by brilliant lecturing, it would seem certain to kill any initial liking the student might have had for the subject.

In many points the author shows his awareness of recent advances. In other features, however, the treatment is far from modern. For example, the graptolites are still classed as coelenterates; various items of his reptilian classification are not in agreement with recent research; the bird classification is an outmoded one; and the mammalian section shows no indication of influence by Simpson or other recent workers.

A. S. ROMER

INVERTEBRATE FOSSILS.

By Raymond C. Moore, Cecil G. Lalicker, and Alfred G. Fischer. McGraw-Hill Book Company, New York, Toronto, and London. $9.00. xiii + 766 pp.; ill. 1952.

It is with unrestricted pleasure that this modern, well-balanced textbook can be announced. It has been written with an unrivalled didactic ability expressed in clear, concise definitions as well as in abundant schematic illustrations. An introductory chapter, The Nature of Fossils, written jointly by the three authors, discusses the types of preservation, the stratigraphic and biologic value of fossils, the principles of classification, and the problems of adaptation, development, and evolution.

The rest of the work is devoted to a thorough presentation of those invertebrate groups which are of paleontological importance. The majority of the chapters has been written by Moore. Lalicker is the author of the Foraminifera and Radiolaria (the only protistids described in detail, for the less important groups are only very briefly reviewed); and of the conodonts, which as a unit of uncertain taxonomic position are placed at the end of the book. Lalicker and Moore have composed the parts dealing with (a) Annelids and Other Worms, under which heading also the conularids are inserted; and (b) the crustaceans, in which the ostracods are amply treated, the remaining crustaceans more cursorily. Fischer has contributed the chapters on cephalopods, holothuroids, starfishes, echinoids, graptolites, and pterobranchs.

Each major unit usually is introduced by a short description of a living representative or of some one typical genus. There follows a detailed morphological and terminological treatment of hard parts, amply illustrated by significant figures. It is surprising what a wealth of information is condensed in text and illustrations. The taxonomic analyses are only short and do not go into details, but the main genera are figured and their definitions are incorporated in the legends of the illustrations. An arrangement of these figures in stratigraphic sequence combines taxonomic and faunistic viewpoints and makes the book useful not only for biologically organized courses but also for those in the stratigraphic applications of paleontology. In some cases there are certain departures from the usual classification, as, e.g., in the treatment of the coelenterates, brachiopods, pelecypods, cephalopods, and crinoids. For the dentition of heterodont pelecypods a "simplified scheme of designation" is introduced, but it might perhaps be doubted whether this is an improvement. Development and evolution, living habits, environment, the geological significance of fossils, are all topics which are adequately discussed, by giving the facts and also by touching upon the open questions and unsolved problems. At the end of each chapter the main literature is listed, and the book itself concludes with a large, thoroughly elaborated index. Nearly all the figures are newly drawn by the authors with immense painstaking. Mostly they are excellent, only a few being unsuitable and uncharacteristic. In any case, it is a pleasure to find original and especially adapted illustrations and not the stereotyped figures reproduced again and again in textbooks all over the world.

To repeat once more: this is a very valuable book of high standard and nearly ideal perfection. Many older paleontologists and geologists will regret that at the time when they were students no such masterly book was at their disposal.

O. H. SCHINDEWOLF

THE PROBLEM OF LAND CONNECTIONS ACROSS THE SOUTH ATLANTIC, WITH SPECIAL REFERENCE TO THE MESOZOIC. *Proceedings of the Symposium on the "Role of the South Atlantic Basin in Biogeography and Evolution," held at the Fourth Annual Meeting of the Society for the Study of Evolution, New York City, December 28 and 29, 1949. Bull. Amer. Mus. nat. History., Vol. 99, Art. 3.*

Edited by Ernst Mayr. American Museum of Natural History, New York. $3.00 (paper). Pp. 79–258 + 2 pl.; text ill. 1952.

Were there former land connections between the southern continents, or did they each receive all their faunistic and floristic elements separately from the north? In case a connection between the continents existed, was it effected by land bridges, or by former contact, subsequently broken by continental drift? These are open questions of historical biogeography, which were to be answered or at least be fully discussed by a Symposium of the Society for the Study of Evolution, organized by N. D. Newell, and with E. Mayr acting as chairman. In order to reach a more concrete foundation for the discussion, the very broad subject was restricted in space and time to the possible connections between South America and Africa and to the Mesozoic Era, since for the Tertiary it seems sufficiently certain that no transatlantic connections did exist.

The problem is attacked from many different aspects of geology, paleontology, and biology. M. Ewing gives a brilliant sketch of The Atlantic Ocean Basin from the geophysical standpoint and states that the existing data are in full agreement with the assumption of the permanence of continents and ocean basins. "There are strong indications against the hypotheses of continental drift and foundered land bridges in the deep ocean basins." Similar conclusions are reached by W. H. Bucher in his discussion of Continental Drift versus Land Bridges. The facts of submarine geology cannot be harmonized with large-scale horizontal drift. K. E. Caster, however, summarizes his very extensive stratigraphic and paleontologic research by saying that the "data now available still are best accounted for by the assumption of a broad continental linkage between South Africa and South America until the end of the Triassic, or possibly into the early Jurassic. By Cretaceous time there is abundant transgressive evidence of the Atlantic Ocean." These conclusions are severely criticized by C. O. Dunbar. A short note by M. Kay concerns the Stratigraphic Evidence Bearing on the Hypothesis of Continental Drift; and G. G. Simpson in an illuminating essay examines, partly on a mathematical basis, the Probabilities of Dispersal in Geologic Time, a topic also dealt with by D. I. Axelrod. In further chapters the fossil floras (Th. Just), the phytophyletic patterns (W. H. Camp), the living invertebrates (P. J. Darlington, Jr.), the biogeography of termites (A. E. Emerson), the fresh-water fishes (B. Schaeffer, D. H. Dunkle), and the Mesozoic terrapods of South America (E. H. Colbert, A. S. Romer) are critically reviewed as to their bearing on the problem. According to Colbert and Romer, the mid-Triassic reptiles favor a transatlantic connection between Africa and South America, while for the Jurassic period the evidence is insufficient. The Mesozoic fishes do not yet allow any solid conclusions. The distributions of mammals and birds does not require a former connection of the two continents; all the available facts are in contradiction with such an assumption. But since these two classes had their main evolution during the Tertiary and latest Mesozoic, they are not suitable to test the question of continental connections in the earlier periods of the Mesozoic.

The Symposium undoubtedly has brought to light a good deal of new facts and insight, although it could not finally resolve the asked questions. With sly humor E. Mayr states in his concluding remarks "that we are in the (for a scientist) always happy situation of still being confronted by unsolved problems."

O. H. SCHINDEWOLF

CRETACEOUS AND TERTIARY FORAMINIFERA FROM THE MIDDLE EAST. *Bull. Brit. Mus. (Nat. Hist.) Geology. Vol. I, No. 8.*

By Thomas Francis Grimsdale. British Museum (Natural History), London. 10s. (paper). Pp. 221–248 + 6 pl.; text ill. 1952.

Fifteen species of Foraminifera are described from different faunal associations of Iraq, ranging from Upper Senonian to Oligocene. One new species is erected in each of the genera *Articulina*, *Austrotrillina* (?), *Heterillina*, *Idalina*, *Lafitteina*, and *Saudia*. *Eorupertia incrassata* is represented by a new "variety." Dealing with the genus *Nummulites*, the author opposes the excessive splitting of species and defends the advantages of lumping. The descriptions are scrupulous, the plates excellent.

O. H. SCHINDEWOLF

CATALOGUE OF THE CENOZOIC PLANTS OF NORTH AMERICA THROUGH 1950. *Geol. Soc. Amer., Memoir 51.*

By Robert S. LaMotte. The Geological Society of America, New York. $5.50. viii + 381 pp. 1952.

The science of paleobotany is notably lacking in works that deal with its taxonomic and bibliographical problems. The only general work that compares in any way with the *Index Kewensis* is the *Compendium of Paleobotany* which exists as a card file in the Paleobotanical Library of the U. S. Geological Survey. This is available for distribution only in microfilm form. It is, therefore,

especially fortunate that LaMotte has undertaken to compile the paleobotanical literature of the North American area. This constitutes the first of three proposed works, the other two of which will cover the Mesozoic and Paleozoic respectively.

This catalogue includes a bibliography and index of all plants described as (Cenozoic) fossils from North America, including Greenland, Mexico, the Central American Republics and the Antilles. It will take the place of Knowlton's *Catalogue of the Mesozoic and Cenozoic Plants of North America* (1917) and of LaMotte's own *Supplement* which brought Knowlton's catalogue up to date through 1937. These catalogues will, however, remain useful for the Mesozoic.

This is a very nearly complete and carefully compiled treatise reflecting, quite obviously, a remarkable command of the literature and of paleobotanical problems. It has been called to my attention that 5 species are omitted (*Eorhachis lomarioides* Arnold, *Osmundites oregonensis* Arnold, *Cyathodendron texanum* Arnold, *Tempskya wyomingensis* Arnold, and *T. wesselii* Arnold), although the paper in which they were described (Arnold, 1945) is cited in the bibliography.

The only adverse criticism that I am able to offer is with reference to the liberty that LaMotte has taken in creating new names and new combinations. Although there will be disagreement on this point, it is my opinion that a catalogue is not the place for revisions of this nature.

Anyone who has not undertaken the preparation of such a comprehensive catalogue can have no concept of the difficulties and chances for error that such an undertaking offers. This is a splendid piece of work, and the author is to be encouraged to complete the two other proposed volumes covering the Mesozoic and Paleozoic.

HENRY N. ANDREWS, JR.

EOCENE NAUTILOIDS OF BRITISH SOMALILAND. *Bull. Amer. Mus. nat. Hist., Vol. 99, Art. 5.*

By Otto Haas and A. K. Miller. American Museum of Natural History, New York. $1.00 (paper). Pp. 317–354 + 11 pl.; text ill. 1952.

The material of this monograph, more than 100 specimens in the Sedgwick Museum at Cambridge, was collected by Macfadyen and Hunt from several horizons and localities. The majority of species belongs to the closely related genera *Cimomia* (6 n. sp.) and *Deltoidonautilus* (3 n. sp.). The genus *Aturia* is represented by one new species only, and a single incomplete specimen is referred with question to *Eutrephoceras*. In the whole at least 16 different species are to be distinguished. None of them seems to be identical with species previously described from elsewhere, and no corresponding assemblages of more than general similarity are known. The closest nautiloid faunas are perhaps those from Senegal and the French Sudan. All the species are amply and excellently illustrated. W. A. Macfadyen has contributed a short note on the geology of the fossil localities.

O. H. SCHINDEWOLF

THE ORIGIN AND HISTORY OF THE BRITISH FAUNA, *With 60 Maps.*

By Bryan P. Beirne. Methuen & Company, London. 18s. x + 164 pp.; ill. 1952.

"An attempt to explain the present composition of the [fresh-water and land animals] of the British Isles, and the distributions, habits, and local variation of representative species of animals, by reconstructing how the animals arrived in these islands and their subsequent histories"—so reads the ambitious introduction. The problem has two aspects: (1) how did the animals reach the islands? and (2) how did they manage to survive the glacial periods? The modes of immigration are given careful but brief treatment, following which the paleontological, historical, ecological, taxonomic, and zoogeographical evidence is sifted to analyze the effects of the Pleistocene on the preglacial fauna, and the various survivors. Survivors of the glacial phase are believed to comprise not more than about 15 per cent of the species. Celtic lands are distinct from the Cambrian, Channel, and Dogger lands; all the latter were largely ice-free. Maritime species include more preglacial survivors, and in a country with so much coast line as the 400-odd islands of the British Isles, this habitat has had good opportunity to influence the present faunal composition. The treatment is highly conjectural, but should help focus attention on the significance of differences in the animal population of Britain as compared with the rest of Europe.

LORUS J. & MARGERY J. MILNE

THE DEER OF THE WEYBOURN CRAG AND FOREST BED OF NORFOLK. *Bull. Brit. Mus. nat. Hist., Vol. 2, No. 1. Geology.*

By Augusto Azzaroli. The British Museum (Natural History) London. 25s. (paper). 96 pp.; ill. 1953.

Since 1868, fossil mammals have been recovered from exposures at sea level on the northern coast of Norfolk, England, having been revealed principally through wave erosion. The current revision of this assemblage of fossils recognizes three separate horizons, the lowest resting on chalk, the uppermost capped by glacial drift. Weybourn Crag is designated as the oldest layer, and is dated Upper Villefranchian. The middle layer is designated as the Estuarine, dated as Second Interglacial, and the upper layer is designated as the Upper Freshwater Bed and dated at a later period of the Second Interglacial. Each layer has a distinctive assem-

blage of deer species. Conclusive aging of the Upper Freshwater stratum is based not on the deer, but on the rodents also found there. In the past, all of these horizons have been at least in part designated as the Forest Bed.

There is a discussion of the phylogeny of deer and the former taxonomy is considerably revised. Two new species are named.

BRYAN P. GLASS

HORSES. *The Story of the Horse Family in the Modern World and through Sixty Million Years of History.*

By George Gaylord Simpson. Oxford University Press, New York. $6.50. xvi + 247 pp. + 30 pl.; text ill. 1951.

This volume is essentially three books synapsed into one. Included are accounts of modern horses, fossil horses, and a discussion of evolutionary theory based on the equid series. On the second and third of these three topics the author is an acknowledged authority. He displays a thorough knowledge of the living animal as well. The book, as is to be expected of its author, is attractively written, and is well illustrated, with a series of 32 plates in addition to text figures. The only thing wrong with it is its price. Even in these days $6.50 is steep for a rather "popular" book of 300 pages designed for the lay reader. I suspect the publisher has "missed the boat" and has lost a potentially much larger audience who might have purchased the book had it not been priced out of its class.

The first third of the volume discusses modern horses from various points of view—wild living horse relatives, ancient and modern breeds, a touch of genetics with horse coat colors as examples, and (gratifyingly) an understandable explanation of horse gaits. Part Two gives the horse evolutionary story, stage by stage. Part Three discusses the various anatomical changes seen in the evolutionary series—in skull, brain, teeth, limbs and feet—and an interpretation of these changes in terms of modern evolutionary theory.

A. S. ROMER

PRIMITIVE FOSSIL GASTROPODS AND THEIR BEARING ON GASTROPOD CLASSIFICATION. *Smithsonian Misc. Coll., Vol. 117, No. 13. Pub. 4092.*

By J. Brookes Knight. Smithsonian Institution, Washington. 60 cents (paper). 56 pp. + 2 pl. 1952.

AUSTRALIAN ARTHRODIRES. *Bull. Brit. Mus. (Nat. Hist.), Vol. I, No. 9.*

By Errol White. British Museum (Natural History) London. 15s. (paper). Pp. 251–304 + 6 pl.; text ill. 1952.

THE TRIASSIC COELACANTH FISH DIPLURUS, WITH OBSERVATIONS ON THE EVOLUTION OF THE COELACANTHINI. *A Study Based on Specimens Collected at Princeton University. Bull. Amer. Mus. nat. Hist., Vol. 99, Art. 2.*

By Bobb Schaeffer. American Museum of Natural History, New York. $1.25 (paper). Pp. 25–78 + 12 pl. + 1 folded table; text ill. 1952.

THE DESEADAN VERTEBRATE FAUNA OF THE SCARRITT POCKET, PATAGONIA. *Bull. Amer. Mus. nat. Hist., Vol. 98, Art. 6.*

By Robert G. Chaffee. American Museum of Natural History, New York. $1.50 (paper). Pp. 507–562 + 12 pl.; text ill. 1952.

GENETICS AND CYTOLOGY

BIOLOGIE DER ZELLE.

By Erich Ries, revised, enlarged, and edited by Manfred Gersch. B. G. Teubner Verlagsgesellschaft, Leipzig. DM. 24.40. viii + 552 pp. + 12 pl.; text ill. 1953.

The science of the cell was hardly born at the close of the last century, when it fell apart into a number of fractions that largely went their own way in ignorance of each other. E. B. Wilson's *The Cell* stands alone in an heroic attempt to create one science of the cell, and perhaps it did not succeed because it did not grow out of a unifying idea. Later attempts to create a synthesis from concepts of one or the other fraction, be it the gene or the colloid, could satisfy only the respective specialists.

As the title suggests, the present book attempts to fill this gap and to give an exposition of all aspects of the living cell. It fails in this because apparently the unifying thought or concept, out of which alone a theory of the cell can grow, is yet unborn. Despite this, it is a most valuable book because it calls to our attention again what the real purpose of cytology should be and because of the wealth of information that it contains in a well organized, thoughtfully selected, and lucid presentation.

All manifestations of life as it exists today are in the end the result of cell activity, and cytology is thus the nucleus of a *general* biology. In the attempt to provide a broad treatment of the cell, the authors succumb to the temptation to include too much, to the detriment of the main purpose of such a book, which should be to give an understanding of the essential properties and activities of a cell. I therefore would wish to see a much broader treatment of the morphology, chemistry, and biochemical properties of the cell components and their functional interrelations, of cellular metabolism, of cell reproduction, and of the role of chromosomes in heredity and evolution which receives just 11 pages out of the 550! Instead, there are 50 pages on experimental embryology and differentiation and long chapters on tumors and tissue culture. The discussion of modern

techniques and approaches might more profitably have been integrated into the general text rather than isolated in a chapter by itself.

The book contains an excellent glossary and index and a list of pioneering contributions in the historical development of cytology. Valuable to the student are the short and precise summaries at the end of each chapter. Many well chosen and well executed illustrations and photomicrographs add to the value of the book.

HANS RIS

ANIMAL CYTOLOGY AND EVOLUTION. *Second Edition. By M. J. D. White. Cambridge University Press, New York.* xii + 432 pp.; ill. 1954.

A new edition of the most outstanding modern book in the field of cytology is always welcome to those who are aware of the paucity of good text and reference literature. The first edition (*Q.R.B.* 21: 377. 1946) brought a refreshing point of view to a subject long dominated by the findings of the *Drosophila* and *Zea* workers and by the interpretations of the Darlingtonian school, while at the same time it incorporated into the body of cytogenetics a tremendous volume of data derived from the study of animal forms having anomalous and often bizarre types of cell division and chromosome behavior. The present volume continues this trend with undiminished vigor. Reorganization, reappraisal, and additions are evident, with the major changes revolving around the more recent data on chromosomal polymorphism in natural populations, the more up-to-date aspects of chromosome chemistry, and the role of hybridization in experimental taxonomy and hybrid sterility. With the recent books by Stebbins, Mayr, and Patterson and Stone, together with the older ones of Darlington, Dobzhansky, and Huxley, White's volume rounds out in admirable fashion the field of evolutionary studies particularly as it applies to the chromosomal behavior of animals. The only gap still remaining is that concerned with the evolutionary aspects of the extranuclear components of the cell, a field that is not likely to be ready for a synthetic approach for some time to come.

C. P. SWANSON

MAMMALIAN GERM CELLS. *A Ciba Foundation Symposium.*

Editor for the Ciba Foundation, G. E. W. Wolstenholme, assisted by Margaret P. Cameron and Jessie S. Freeman. Little, Brown & Company, Boston. $6.75. xvi + 302 pp. + 15 pl. 1953.

The most productive type of scientific meeting is no doubt the gathering of a small number of workers from various fields, living together for several days to discuss a problem of mutual interest. For some years now the Ciba Foundation in England has organized such symposia on an international basis. The present volume contains the record of the presentations and informal discussions of a symposium in which biochemists, zoologists, veterinarians, and medical men gathered to exchange information on theoretical and practical aspects of the biology of spermatozoa and ova in mammals. For one thing, it shows that at least in some fields the gap from the fundamental knowledge to its practical exploitation may be shorter than it often has been. The close connection between the biochemical, cytological, and physiological studies and the problems of the animal breeder and physician is one of the interesting aspects of this volume. The biologist will find here an authoritative summary of what is known about the metabolism of spermatozoa, the conditions for their survival, the physiology of sperm movement, sperm transport in the female, and fertilization of the ovum, the cytology of maturation in the egg, of ovulation, and development of mammalian ova in vitro. Most striking, perhaps, is the success in the almost indefinite preservation of frozen spermatozoa and the promising results with transplantation of frozen stored ovaries. These foretell the most far-reaching control over the reproduction of domestic animals and also the possibility of unrestricted control over human reproduction. In his Foreword, S. J. Folley concludes with a note of apprehension which dampens the satisfaction over the achievement of science: "The technical advances foreshadowed by the researches reported in this volume are primarily envisaged as applicable to stock-breeding. The fact must be faced that they can also be applied to man, and society will have to consider seriously how best to handle these new possibilities, which may be fraught with as much significance and danger of misapplication as the discovery of how to release the energy of the atomic nucleus."

HANS RIS

RACE CROSSING IN MAN. *The Analysis of Metrical Characters. Eugenics Laboratory Memoirs, XXXVI. By J. C. Trevor. Cambridge University Press, New York.* $2.50 (paper). ii + 46 pp. + 1 pl. + 1 folded chart; text ill. 1953.

This monograph collects the data on measurements of the dimensions of various races and their hybrids. The author is quite discriminating in his evaluation of the statistical significance of the populations studied by the various anthropologists. Elimination of the poorly ascertained samples leaves a solid body of data which behave according to orthodox genetic expectations. In stature, head length, or any of the other measurements or indices used, the hybrid is intermediate between the parental races. The differences between the

variabilities of the hybrids and of the parental races were extremely small.

One would expect that the result of racial crosses, as measured by visible metrical characters, would be a new population intermediate in its mean measurements between those of the originals. This is exactly what Trevor finds to be the case in almost all of the instances he examines. He has been able further to demonstrate that many earlier speculations about the supposedly peculiar effects of racial mixture are quite unfounded.

SHELDON C. REED

A STUDY IN MANIC-DEPRESSIVE PSYCHOSIS. *Clinical, Social and Genetic Investigations. Acta Psychiat. Neurol. Scand., Suppl. 79.*

By Åke Stenstedt. From the Psychiatric Clinic of Karolinska Institutet, Stockholm; [Ejnar Munksgaard, Copenhagen]. Sw.Kr. 20.00 (paper). vi + 111 pp.; ill. 1952.

The data on the genetics of manic-depressive psychosis, presented in this slightly anemic Scandinavian monograph, are based on an investigation of the inhabitants of an isolated North-Swedish district (Northern Bohuslän). The population, from which a series of 216 hospitalized manic-depressive index cases (probands) was drawn, decreased from 56,950 to 43,750 persons during the period covered by the study (1919–1948). The total sample investigated, comprising the probands as well as their parents, siblings, spouses, and children, consisted of 2,325 persons. The 72 cyclic psychoses observed in the proband families were equally distributed between the sexes. The clinical criteria used in diagnosing a cyclic psychosis were consistent with the Scandinavian system of psychiatric classification and probably a little less restricted than those evolved in recent American twin studies. Nevertheless, the nature and distribution of the psychoses observed in the author's index families fully confirms my own twin-research finding of a strictly specific vulnerability to manic-depressive psychosis, apparently associated with the mutative effect of a single dominant gene with incomplete penetrance. In the words of the author, there was no evidence of "a genetic relationship between manic-depressive psychosis and any other psychosis or psychic abnormality."

The total expectancy of manic-depressive psychosis among the sibs, parents, and children of manic-depressive index cases was found to approximate 15 per cent, "if the results of previous investigations are considered together with the results of the present study." By contrast, the general morbidity risk was relatively high (about 1 per cent), that is, virtually as high as the general population rate reported by other Scandinavian investigators. It would be difficult to say, of course, whether the specifications of these morbidity figures might be attributable mainly to certain qualifications of the diagnostic system used or to the non-urban character of the populations investigated.

Of particular interest was the observation that even in a rural population, manic-depressives appeared to have a lower marriage rate than the general population. Their mortality was found to be increased, while the fertility of married patients failed to reveal a significant decrease. To no one's surprise, the social status of the children and sibs of cyclic index cases did not "deviate remarkably from the average population."

The homogeneity of the manic-depressive genotype was demonstrated by the absence of differences in morbidity risk between the sibs of the male and female probands, and between the sibs of probands with only one manic and only one depressive episode. On the other hand, the morbidity risk for the sibs of "purely" cyclic probands was found to be higher than that for the sibs of probands distinguished by some "disturbing elements" such as peculiar personality traits or schizophrenia-like symptoms. Certain environmental adversities in childhood were interpreted by the author as having the tendency to "increase the risk for the psychosis among the siblings of the probands." Clinically, it may not have been without significance that 53 per cent of all the cyclic cases ascertained in the study had only one psychotic attack. It was in accordance with expectation, however, that the first attack observed was a depression in 83 per cent of the cases.

The main contribution of the study may be seen in a detailed and repletely tabulated substantiation of the genetic theory of manic-depressive psychosis. A careful review of the pertinent European literature is equally meritorious. Whatever disappointment is evoked by this diligent but ultraconservative investigation is chiefly due to some excellent opportunities missed procedurally. There are five appendices with pedigrees and psychiatric case histories, and brief references to 14 twin pairs who occurred among probands and their sibs.

FRANZ J. KALLMANN

FOLIA HEREDITARIA ET PATHOLOGICA. *Vol. I, Fasc. 1–4.*

Edited by Alfonso Giordano, and 12 coeditors. Instituto di Anatomie e Istologia Patologica dell'Universita di Pavia. L. 3500 or $9.00 per vol.; single numbers, L. 1000 or $2.00. 345 pp. + 36 pl. + 1 folded chart. 1951–1952.

Since the end of World War II the rapidly growing interest in human and medical genetics has been manifested in a surprising number of new journals in that field. *Folia Hereditaria et Pathologica* is one of these. Four or five numbers, of about 100 pages each, will comprise a volume. Volume One contains 22 original papers, of which all but 2, which are in English, are in Italian with brief English summaries. Two issues

contain book reviews, also in Italian, and one contains a bibliography of the Rh literature. The quality of the paper is rather poor, and although halftones are on glossy stock, they are not outstanding in quality. One plate is in color.

BENTLEY GLASS

GENERAL AND SYSTEMATIC BOTANY

INTRODUCTORY PLANT SCIENCE.

By Henry T. Northen. The Ronald Press Company, New York. $5.50. vi + 601 pp.; ill. 1953.

PLANTS AND THE ATMOSPHERE. *Harvard Case Histories in Experimental Science. Case 5.*

By Leonard K. Nash. Harvard University Press, Cambridge. $1.50 (paper). x + 122 pp. + 1 flow-chart; ill. 1952.

The sequence of topics in this book follows the usual pattern, with the exception of Chapter 3, which is an early, brief look at the form and growth of seed plants. The first chapters deal with botany and human affairs and with a general view of the kinds of plants. Chapter 4 is on cells. Then follow 3 chapters on physiology, 5 on the structure of higher plants, 4 more on physiology, 4 on reproduction, 1 on physiology of flowering, 3 on genetics, 3 on ecology and conservation, 1 on evolution, and 11 on the different groups of plants. Scattered through these later chapters are a few discussions of the practical importance of some plants.

This book is more a compilation than it is a book of science, as the title states. Almost no reasoning about the reported facts is presented. Practically nothing in the book would teach a student that science is an exciting intellectual activity in which facts and ideas are in a constant turmoil. Nor is there anything to teach him that the major aim of science is to create theories of broader and broader significance. The existing theoretical framework which gives meaning and organization to so many facts in botany is not explicitly discussed, and one does not find or feel its presence in the book.

It is true that these statements can be applied to most botany textbooks, but this fact does not make the present book more scientific. The history of botany is full of excellent examples of facts and theories in active interplay. Modern advances in botany supply still more examples of science in action. Why do these not find their way into botany textbooks, so that botany can be taught and understood as a dynamic, growing part of science? One cannot say it is impossible to teach these things, for they are already being taught to beginning students. For a good, if lengthy, example, see L. K. Nash, *Plants and the Atmosphere.*

If one examines Northen's book as a presentation of facts, one finds that it is simply and clearly written and well illustrated. Most of the pictures are very good, a few are bad, and more than a few are excellent. Most of the photographs are original. Some subjects of general significance that could well have been included are: the growth curve as descriptive of individuals and populations, other enzymes besides the digestive enzymes (which were well treated), nutrition as a general problem, the more recent views on photosynthesis, and a more thorough and more modern view of evolution.

RALPH W. LEWIS

AUSTRALIAN JOURNAL OF BOTANY. *Volume 1, Number 1, March 1953.*

Edited by N. S. Noble. Commonwealth Scientific and Industrial Research Organization, East Melbourne. 7s. 6d. per issue. (Vol. 1, No. 1) 184 pp. + 19 pl.; text ill. 1953.

This recent addition to the now extensive series of scientific journals published by C. S. I. R. O. in Australia will appear at irregular intervals, as material justifies. The contents will present the results of original research in botany, particularly in its descriptive aspects. The first issue contains the following articles: The Anatomy of the Timbers of the South-west Pacific Area. II. Apocynaceae and Annonaceae (H. D. Ingle and H. E. Dadswell); The Occurrence of Heartwood Crystals in Certain Timbers (M. Margaret Chattaway); Objective Methods for the Classification of Vegetation. I. The Use of Positive Interspecific Correlation (D. W. Goodall); The Identification of the Sporomorph *Phyllocladidites* with *Dacrydium* and its Distribution in Southern Tertiary Deposits (Isabel C. Cookson); The Tertiary Occurrence and Distribution of *Podocarpus* (Section Dacrycarpus) in Australia and Tasmania (Isabel C. Cookson and Kathleen M. Pike); The Rate of Podzol Development in Sands of the Woy Woy District, N.S.W. (A. Burges and D. P. Drover); The Biology of St. John's Wort (*Hypericum perforatum* L. var. *angustifolium* DC) in the Ovens Valley, Victoria, with Particular Reference to Entomological Control (Nancy Clark); The Genus *Triodia* R. Br. (Gramineae) (Nancy T. Burbidge).

MARINE ALGAE. *The John Murray Expedition 1933–34, Scientific Reports, Vol. IX, No. 5.*

By Linda M. Newton. British Museum (Natural History), London. 9s. (paper). Pp. 395–420 + 4 pl. 1953.

A REVIEW OF NOMENCLATURAL CONSERVATION IN THE ALGAE FROM THE POINT OF VIEW OF THE TYPE METHOD. *Univ. Calif. Publ. Bot., Vol. 25, No. 4.*

By Paul C. Silva. University of California Press, Berkeley and Los Angeles. $1.25 (paper). Pp. 241–324. 1952.

CONTRIBUTIONS TO OUR KNOWLEDGE OF OLD WORLD ARALIACEAE: *An Undescribed Species of Mastichodendron (Sapotaceae) from Barbados and Antigua. Bull. British Mus. (Nat. Hist.)., Bot., Vol. 1, No. 1.*

By W. R. Philipson, H. E. Box, and W. R. Philipson. British Museum (Natural History), London. 5s. (paper). 24 pp. + 1 pl. 1951.

A REVISION OF THE WEST INDIAN SPECIES OF SELAGINELLA: *A New Species of Cheilanthes from Africa and Some Additions to the Fern Flora of Northern Rhodesia. Bull. Brit. Mus. (Nat. Hist.); Vol. 1, No. 2.*

By A. H. G. Alston. The British Museum (Natural History), London. 8s. (paper). Pp. 25–50 + 1 pl. 1952.

To the several excellent new series of Bulletins of the British Museum (Natural History), there is now added a series in Botany. The format is uniform with that of other series, except that this one is distinguished by having a green cover. Excellent typography, fine plates, and careful editing mark these series. The individual parts of each volume of three to four hundred pages will appear irregularly and be priced separately, a very commendable feature. The *Quarterly Review of Biology* will review the more substantial contributions in these five series.

FLOWERS OF THE SOUTH, *Native and Exotic.*

By Wilhelmina F. Greene and Hugo L. Blomquist. The University of North Carolina Press, Chapel Hill. $5.00. xiv + 208 pp. + 27 pl.; text ill. 1953.

There seem to be just as many flower-lovers south of the Mason and Dixon Line as there are north of it, but there certainly are fewer good wild-flower books for Southerners to choose from. Mrs. Greene and Dr. Blomquist have prepared a book which will serve that host of people who enjoy seeking out and identifying flowers in the southeastern states. Anyone who counts himself in this group would do well to have a copy.

The book should be excellent for the amateur, since of over 500 species which are described, nearly all are illustrated with pen-and-ink drawings that occupy the marginal third of each page alongside the text description. The drawings are large and clear, and for many flowers identification is possible by means of the drawing alone, although the accompanying text makes identification more certain as well as describing and differentiating species similar to the one illustrated. Besides the pen-and-ink drawings, about fifty species are illustrated individually in color. A unique feature of the book is the inclusion of 11 full-page color plates of groups—really, bouquets—of flowers that are to be found at some certain season in any one of the various natural areas—"Spring wild flowers of the Southern Coastal Plain," midsummer flowers of the mountains, fall flowers of the coastal plain, etc. On the facing page is a labeled outline drawing of the flowers shown on the color plate. If the purpose of these bouquet color plates was to aid in identification, they are not a success; but they certainly are attractive and pleasing to anyone who already knows the profusion of flowers that are illustrated on each plate.

The last quarter of the book is devoted to exotics, of which the selection and illustrations are as good as for the wild flowers. Looking at this section I am compelled to think not of the Southerners (most of whom already know their cultivated flowers), but of the Northerners, particularly those who garden, who come south and are bewildered by the profusion of unknown flowering plants they see in southern gardens. They will naturally notice the conspicious and uniquely southern species, and it is these that are illustrated and described.

There are no taxonomic keys in the book, but the flowers are arranged in the normal sequence of families, and there is a complete index of common and scientific names. A beginner will probably identify an unknown flower by flipping pages and looking at the pictures, anyway, and the more expert person usually knows which family a plant is in—in either case the plant can be worked down readily to its genus, and usually its species. The drawings have a negative advantage, too. If you can't identify some unknown flower you can at least be sure it is *not* one of these described and illustrated in the book.

It is gratifying that the authors have realized that most of the people who will use this book, once they have identified a species, will want to know more about it. Along with each description, they tell which species can be transplanted easily (and which cannot, or only with difficulty), what are the preferred growing conditions, which species last well as cut flowers and which wilt quickly, and how to cut flowers and prepare them for bouquets. It is obvious that the authors have an interest in flowers beyond the purely scientific one of taxonomy and identification.

ALAN D. CONGER

PLANT MORPHOLOGY

PLANT MORPHOLOGY.

By Arthur W. Haupt. McGraw-Hill Book Company, New York, Toronto, and London. $8.00. x + 464 pp.; ill. 1953.

This book fills a definite need among botany texts because it presents in a single volume an "above-the-introductory-level" survey of the plant kingdom. Heretofore, for a course in plant morphology based upon a survey of the plant kingdom at an intermediate level, it has been necessary to use either a general botany textbook or selected materials from a complement of several advanced works. The disadvantages of both of these alternatives are obvious.

The author treats "the principal groups of plants

from the standpoint of their structure, reproduction and development." The survey emphasizes "relationships as revealed by basic similarity in bodily organization and life histories," and gives an "account of the general course of evolution that existing groups appear to have followed."

An introductory chapter presents general aspects of classification and the plant life of the past. The remaining subject matter is organized under 9 chapters which treat the algae (2 chapters), fungi, bryophytes, pteridophytes (2 chapters), spermatophytes (2 chapters), and, finally, the evolution of the plant kingdom. The composition of the chapters is consistent. A brief summary follows the description of vegetative and reproductive characteristics for each subdivision (generally orders) of the main groups. These summaries are chiefly restatements of outstanding characteristics noted in the descriptions, but they may be useful. The sections on General Conclusions, which follow the treatment of each of the main groups, are of greater value for the interpretations and correlations they present. Over 300 drawings and photographs, most of them new, adequately illustrate the text.

From a general point of view the treatment of individual orders, as based upon representative genera, is fairly comprehensive. Some orders, such as the Tetrasporales of the green algae and the Voltziales and Caytoniales of the gymnosperms, are omitted. In comparison to the treatments of the groups of living plants, those of fossil plants are generally brief and to some extent inadequate.

A few misleading statements were noted. It is implied that the distribution of truffles in this country is restricted to California. Sieve tubes rather than sieve cells are indicated as phloem elements in the pteridophytes and conifers. The terms stamen and carpel are used to refer to the spore-bearing structures of gymnosperms as well as angiosperms. Although there is precedent for this, it is more common to restrict these terms to angiosperms. Furthermore, the spore-bearing structures of seed plants are indicated as being homologous with those of the pteridophytes. In one sense this may be valid, but in the light of the non-foliar nature of sporangium-bearing structures in the Psilotales and *Equisetum*, and the fact that leaves of the lycopods and seed plants presumably have different morphological origins, there is strong reason to question it.

The chapter on the evolution of the plant kingdom is a valuable part of the book. It is chiefly devoted to the evolutionary tendencies in the different plant groups, the evolution of sex, and alternation of generations. Here, as well as in other chapters where such topics as evolution and relationships are considered, however, the attempt to present evidence for opposing views and to evaluate them is not always made. For example, no recognition is given to the interpretation that the gametophyte of the bryophytes may have evolved by reduction and modification of an erect, radially symmetrical type and that the simpler sporophytes in the group may also be reduced. Alternation of generations is discussed in favor of the antithetic theory without review of the evidence from the lower vascular plants which would seem to be pertinent to the question. No mention is made of the telome theory. There may indeed be limitations in its application, but it would seem that a recognition of the concept and of the significant contributions in modern morphology that have resulted from its application would have been appropriate.

The classification in the book recognizes the main divisions of Phycophyta and Mycophyta under the subkingdom Thallophyta, and Bryophyta, Pteridophyta, and Spermatophyta under the subkingdom Embryophyta. Newer alternative classifications are discussed, but they are dismissed as being no more adequate. The supposed advantage of the newer classifications rests in the fact that they more accurately reflect phyletic lines, particularly among algae and vascular plants, and, therefore, they would be ideally suited to a book which emphasizes evolution and relationships.

Agreement on matters which involve interpretation is not always to be expected. Many teachers will, no doubt, agree with most of the author's views. There is no question that the book will afford a sound basis for a morphological survey of the plant kingdom. If desired, it can be supplemented by readings from the selected references which are given.

CHARLES HEIMSCH

DEVELOPMENTAL PLANT ANATOMY. *A Workbook for Use in a General Course.*

By Richard A. Popham. Long's College Book Company, Columbus. $4.50. xxix + 361 pp.; ill. 1952.

Developmental Plant Anatomy is a laboratory workbook for use in a general course by students from all fields of plant science. As indicated by the title, the emphasis throughout is on anatomical aspects of plant development, the objective being to formulate, from a study of all plant parts, "a concept of the structural changes occurring during the enlargement of the plant from a fertilized egg." The importance of physiological facts and concepts to an understanding of the development of plant structure is recognized, and the individual instructor can correlate observations and inferences with other plant science fields as he may desire.

The book is in loose-leaf form, and thus the sequence of topics may be modified and additional material inserted. In the arrangement presented roots are considered first, followed in order by the hypocotyl, stems, leaves, and cell types. A large number of references is coded under different subjects, and the student is repeatedly referred to them when they are appropriate. Many topics are supplemented by compilations of data,

some extensive, in the form of charts, notes, and summaries. In these, source references are cited only by author and date. There is an appendix which consists of a review of the principal types of vegetative shoot apex organization in vascular plants.

Noteworthy are the many excellent photomicrographs of the materials observed, included in order to allow the time of the student to be more profitably devoted to observation, discussion, etc. They are intended to be labelled by the student.

More noteworthy, perhaps, is the fact that the approach to the laboratory work places a premium on critical observation. This emphasis is heightened by the absence of directions and outlines of procedures. The attention of the student is focused by a series of questions which demand accurate observations and thoughtful evaluations. Many of the questions presuppose information that cannot be obtained from the subject material, and hence background information must be utilized.

In general, the approach is directed toward two rather opposed achievements—an elucidation of the principles of developmental plant anatomy and an appreciation of the variations in plant structure. Because of the attention to factual aspects in the questions and the abundant data given for most of the sections, the student might tend to emphasize details at the expense of the principles. With skilful direction on the part of the instructor, however, both goals could be realized.

A wide representation of rather commonly available specimen materials is indicated. Selections among these can be made, if desired, without sacrifice of results.

The workbook was prepared by offset printing from a typewritten manuscript and the appearance is pleasing. Only a few typographical errors were noted.

Although coverage of the subject is broad, certain anatomical topics are treated slightly, if at all. Among these may be mentioned cell wall structure, cellular organization of and ontogenetic modification of the cambium, details of structure and development of xylem elements, nodal structure, and types of secretory structures. Sieve cells are not included as a cell type and the concept of tracheary elements is not clear. The topic of the specialization of tracheary tissues and its application to phylogeny is not considered. These various aspects may be judged as relatively unimportant in a study of developmental anatomy, but many of them are basic to a broad foundation in anatomy and are significant in developmental phenomena. The serious student would obtain some of this information while reading the literature.

The workbook represents a real contribution to the teaching of plant science. Although the approach is not new, it is certainly a fresh one. If used within the proper framework it should provide a sound training for the student and a stimulating experience for the instructor.

CHARLES HEIMSCH

THE MOLECULAR ARCHITECTURE OF PLANT CELL WALLS.

By R. D. Preston. John Wiley & Sons, New York. $6.75. 211 pp. + 16 pl.; text ill.; 1952.

This small, well illustrated volume was written "chiefly for botanists." Although there are brief chapters dealing with the historical development of cell wall research and with the chemical nature of cellulose and other constituents, the bulk of the volume is concerned with polarization optics and x-ray crystallography, and with their applications in the study of the walls of different types of plant cells.

Present concepts of the visible and submicroscopic structures of cell walls should be based upon a summation of evidence derived from many diversified lines of investigation. Each technique has particular advantages and limitations. Most of them involve more or less drastic treatments in preparing material for examination. To rule out certain of them as "completely inadequate" without clearly defining the limitations and uncertainties of others is scientifically unjustifiable. In the application of polarization optics and x-ray crystallography, various mistaken inferences have been drawn in the past owing to unfamiliarity with the numerous variables in botanical material. Certain of these misconceptions are rectified in Preston's volume and are brought into close harmony with other lines of evidence.

I. W. BAILEY

ECONOMIC BOTANY

MATERIAE VEGETABILES. *Acta Culturae et Praeparationis Planatarum. Organ of the International Commission for Plant Raw Materials. Vol. I, No. 1. Edited by C. Regel and Fr. Tobler. Publisher, Dr. W. Junk, Den Haag.* Subscription per. vol. (4 nos.), Fl. 40.–[Dutch guilders]. (1) 128 pp.; ill. 1952.

Following the Introduction (in English, French, and German) to this new journal, the first issue contains the following articles: Karroid and Karoo Veld as Nutrition to Farm Animals (M. Henrici); Der Lein als Oel- und Faserpflanze des La Plata-Gebietes (A. Boerger); Die wissenschaftlichen Grundlagen der Harznutzung und ihre praktischen Auswirkungen (K. Mazek-Fialla); The Caesalpinias as Tanning Materials (F. N. Howes); Über den Einfluss der Düngung auf die Faserentwicklung der Yuccapflanze (A. Th. Czaja); The Significance of Terpene Accumulation in Plants (J. P. Riches); Die Verwertung der Fasern von Stammen der essbaren Bananen (Fr. Tobler); Le Styrax en Grèce (Ch. Diapoulis); The International Commission for Plant Raw Materials (C. Regel). A number of short reviews of books, monographs, and important articles concludes the issue.

The aim of the new periodical is to bring together the previously widely dispersed literature dealing with the research, cultivation and extraction, amelioration, preparation and utilization of plant raw materials. Articles will be published in English, French, German, Italian, or Spanish, and each will have a summary in a second language. The journal is very well printed on good paper, and papers are illustrated by line cuts. The four numbers per annum will comprise about 400 pages, 100 per issue.

TEXTBOOK OF WOOD TECHNOLOGY. *Vol. 2. The Physical, Mechanical, and Chemical Properties of the Commercial Woods of the United States.*

By H. P. Brown, A. J. Panshin, and C. C. Forsaith. McGraw-Hill Book Company, New York, Toronto, and London. $10.00. xxviii + 783 pp.; ill. 1952.

This volume (Vol. 1, *Q.R.B.*, 25: 335. 1950) gives a comprehensive discussion of the physical and mechanical properties of wood, and was written primarily for foresters, engineers, architects, and others concerned with the industrial utilization of wood. The book is in three parts: 228 pages are devoted to the general physical properties of wood, and 492 pages to its mechanical properties, while the discussion of chemical properties is condensed into 40 pages. It appears to me that the chemical part of the book is excessively abridged in comparison with the physical parts, and should have been omitted and reserved for adequate treatment in a third volume of the series.

I. W. BAILEY

FLOUR FOR MAN'S BREAD. *A History of Milling.*

By John Storck and Walter Dorwin Teague; illustrated by Harold Rydell. University of Minnesota Press, Minneapolis. $7.50. xiii + 382 pp.; ill. 1952.

The history of milling is much more than the history of an important industry; it is in part a history of civilization itself. The ways in which man first utilized cereal grains for food, the primitive methods of grinding the grain into flour, and the later improvements due to technological progress have profoundly influenced man's social development.

Flour for Man's Bread tells in a most interesting manner the story of the gradual advance of the art of milling, from the first crude attempts at grinding in Paleolithic times to the complicated automatic mills of the present day. The detailed account begins with the ancient civilizations of the Tigris, Euphrates, and Nile Valleys, and later of Greece and Rome, goes on to the more modern periods of European history, and thence to America.

Quite naturally the gradual improvement of the technical processes involved constitutes the principal theme of the book. Since, however, these advances have gone hand in hand with the development of man's intellectual powers, students of social and economic history, geography, archeology, economic botany, agriculture, and related subjects will find the work of compelling interest.

So much factual information and so many important steps are given here—the first use of shaped stones (mortars and saddlestones), of screens to sift the husks from the meal, of querns and millstones to reduce rather than grind the grain, and the more recent innovations in tools and techniques—that a reviewer is faced with a most difficult task. Possibly a recapitulation of the especially descriptive chapter headings will suffice to give some idea of the scope of the work: Foreword; The Line We Shall Follow; Diet Makes the Man; The Grinding of Wild Grains Begins; Grain Cultivation Begins: Farming and Milling Tools Appear—and Bread; The Grain Empires; Milling Becomes a Business; Water Turns the Millstones; Man Masters the Winds for Milling; Man's New Power Resources; Milling Comes to America; Oliver Evans Invents the Automatic Mill; Westward Ho!; Automatic Milling and the Purifier Start a Revolution in American Milling; Rollers and Gradual Reduction Advance the Milling Revolution; The Automatic All-Roller Gradual-Reduction Mill Completes the Revolution; The Business Side of Milling Gains Importance; The Modern Mill and its Flour; The New Era of Organization and Research; Looking Forward. There is also a glossary of Milling Terms, a section devoted to references and notes, and an index. The work is well illustrated and admirably printed.

After the reader has finished the book—and he will want to finish it—he will be left with a vivid series of pictures of the "ancient and honorable craft of milling from earliest times to the present day." This is not surprising, since much of the fundamental research involved in its preparation was carried out with the intention of incorporating the results in a Museum of Milling with a series of dioramas to tell the story—a project which was later abandoned.

The great majority of the facts stated seem to be well documented, save possibly in the earlier chapters. Here some of the archeological evidence may seem to be rather inconclusive, particularly in regard to dating. The author's recognition of the far-reaching importance of the development of agriculture on man's history, however, is most commendable.

ALBERT F. HILL

THE FUNDAMENTALS OF FRUIT PRODUCTION. *Third Edition.*

By Victor Ray Gardner, Frederick Charles Bradford, and Henry Daggett Hooker. McGraw-Hill Book

Company, New York, Toronto, and London $9.00. xiv + 739 pp.; ill. 1952.

This third edition of a book that first appeared in 1922 (2nd edition, 1939) was the first book of its kind which focused attention on the fruit plant itself, its growth, and its requirements. Plant physiology, plant chemistry, soil science, and physics were freely drawn upon. The presentation was based on the more significant researches and experiences in the field, as the authors judged them. In contrast, most books on fruit culture up to that time had dealt principally with common orchard practices. The book has proved exceedingly valuable to students and professional horticulturists, by serving primarily as a source book and reference to much material scattered widely throughout the literature in many disciplines.

The third edition has been prepared by the senior author, the junior author having died. It differs from the second in that additional information is included in each chapter in an attempt to bring each up to date. Furthermore, there is a new section of 25 pages dealing with light relations and another of 23 pages dealing with growth regulators. On the other hand, sections formerly dealing with propagation, stock and scion relations, and geographical influences have been removed in order to keep the book within the space limits of the original edition.

It is unfortunate that it was found necessary to remove the sections on propagation and geographical influence. They are important and significant in fruit culture, and all readers of the book would have been pleased to have seen these areas expanded and well treated. Light relations and growth regulators are discussed only briefly. The literature citations are not overly well selected and do not include the most recent research. In attempting to bring the other chapters up to date, the author has quite naturally rested heavily upon literature and research reported in the first edition (1922). Coverage of the literature from that period until 1952, however, leaves much to be desired. The book will find great value, as it always has, as a reference book of the earlier literature, and it contains sufficient new material to increase its value somewhat.

H. B. TUKEY

ANNUALS FOR EVERY GARDEN.

By Dorothy H. Jenkins; photographs by Gottscho-Schleisner, drawings by George L. Hollrock. M. Barrows & Company, New York. $3.00. 223 pp. + 16 pl.; text ill. 1953.

The gardener who wishes a colorful display of blooms from early spring to killing frost recognizes the value and necessity of annuals. For cut flowers they are, of course, indispensable. Yet the lack of variety that characterizes most gardens is rather remarkable when one considers the truly splendid array from which selections can be made, as well as the ease with which annuals other than zinnias and marigolds can be grown. The author, who from her experience as garden editor for the New York *Times*, writes with assurance and authority, takes up all phases of home cultivation from soil preparation to the arrangement of altar pieces. A month-by-month calendar of chores is provided for the forgetful, and an excellent and compact guide at the end of the book summarizes much of the information in usable form. This is a handy book to supplement, though not to replace, the annual seed catalogues.

C. P. SWANSON

GLOXINIAS—*And How To Grow Them.*

By Peggie Schulz. M. Barrows & Company, New York. $2.95. 128 pp. + 6 pl.; text ill. 1953.

Gardeners, like stamp collectors, eventually reach a stage of specialization; having reached that stage they unite for common comfort and benefit to form a club; having formed a club, national affiliation becomes inevitable and indeed vitally necessary; such widespread interest leads to the founding of a journal, in this case *The Gloxinian*; a book follows as day follows night. The current gem, first of its kind, is complete from an historical, botanical, and cultural treatment to inclusion of a facsimile membership blank for those who would seek entrance into the national society. It is destined to enjoy a measure of success which can be accurately calculated from the membership rolls of the national society. Being a first, or possibly a second, cousin of the African violet, the gloxinia has a blood advantage over other flowers as regards popularity. Being somewhat finicky house plants, they also present a challenge to the indoor gardener. The style of presentation is friendly and feminine but not frivolous. The volume is recommended as a birthday present for distaff members of the family at, or beyond, the age of forty.

C. P. SWANSON

PLANT CHEMOTHERAPY AS EVALUATED BY THE FUSARIUM WILT ASSAY ON TOMATOES. *Conn. Agric. Exp. Sta. Bull. 557.*

By A. E. Dimond, David Davis, R. A. Chapman, and E. M. Stoddard. The Connecticut Agricultural Experiment Station, New Haven. Free (paper). 82 pp.; ill. 1952.

GENERAL AND SYSTEMATIC ZOOLOGY

SYSTEMATIC ZOOLOGY. *Vol. 1, Nos. 1–4. 1952.*

Edited by John L. Brooks. The Society of Systematic Zoology, U. S. National Museum, Washington.

Subscription: members, $4.00; non-members and institutions, $7.00. Single numbers, when available, $1.50 (members), $2.00 (non-members). 1952.

This new quarterly has a threefold purpose: "to publish, and therefore to encourage the preparation of, contributions on basic aspects of all fields of systematics, principles and problems; to provide a suitable forum for discussion of the problems of the systematist and his methods; and to report as news the other activities of the Society of Systematic Zoology." Contributions will deal with the principles of systematics and their applications in comparative anatomy, zoogeography, paleontology, taxonomy, classification, evolution, or genetics; discussions of methods, problems, and activities of systematists; reviews of new books and monographs; and news of persons and organizations, research and teaching programs, expeditions, collections, meetings, etc.

Volume I contains 22 articles, ranging from discussions of general methods or nomenclatural problems to such specific contributions as the Zoogeography of the Bathypelagic Fish, *Chauliodus*, (R. E. Haffner) or Hybridization in the Purple Grackle, *Quiscalus quiscala* (C. E. Huntington). Excellently printed on fine paper stock, and illustrated with line cuts and occasional halftone engravings, the journal presents a fine appearance and will undoubtedly fill a very useful place in the zoological literature. Volume I contains about 185 pages.

ANNOTATED LIST OF ANIMALS AND PLANTS OF MIE PREFECTURE, JAPAN.

The Committee of The Biological Survey of Mie Prefecture. Paper. x + 352 pp. + 5 pl. 1951.

This list of thousands of plant and animal species, arranged by taxonomic groups, bears witness to the rich fauna and flora of Mie Prefecture, even though the list is admittedly incomplete. The scientific names of the species and higher categories are given in the customary Latin or Greek forms, but the annotations are in Japanese.

THE BIOLOGY OF PARAMECIUM.

By Ralph Wichterman. The Blakiston Company, New York and Toronto. $9.00. xvi + 527 pp.; ill. 1953.

In this age of intensive research, when specialization is the order of the day, books that attempt to summarize active areas have an important place in scientific literature. These books serve as useful handbooks for the worker in the field and present the essentials of that area to the general scientific reader.

That the biology of *Paramecium* deserves such treatment needs no defense. These ciliated protozoa aroused the wonder of the early microscopists, stimulated the 19th century cytologists, and are now under study from every biological angle. These unicellular "slipper" animals are largely responsible for our recent attention to cytoplasmic heredity, are now making contributions to our understanding of cellular differentiation, and promise to make even greater contributions in the future.

The scope of *The Biology of Paramecium* is commendable. The author has brought together some 2,000 references dating from 1674 to the present. Starting with a history and classification of the genus, he discusses its morphology, cytology, ecology, physical and chemical properties, metabolism, reproduction, and genetics. Every facet of the biology of the organism is mentioned somewhere in the text, making this an exceedingly useful reference work for the reader with a particular interest.

However, the value of this important contribution to biological literature would have been enhanced had the author revised the text a few more times. This might have improved its readability and tightened its organization. It might also have decreased the repetitiousness of some sections and have increased the emphasis on recent and more important findings in place of more inconsequential material.

MYRON LEVINE

THE CESTODES OF SEALS FROM THE ANTARCTIC. *Brit. Mus. (Nat. Hist.) Zool., Vol. I, No. 7.*

By Stanislaw Markowski. The British Museum (Natural History), London. 12s. 6d. (paper) Pp. 125–150 + 12 pl. 1952.

Nine species of pseudophyllidean cestodes occur in Antarctic seals. They belong to 4 genera, 2 of which are new. One new species is described.

A HISTORICAL REVIEW OF THE MOLLUSKS OF LINNAEUS. *Part 2. The Class Cephalopoda and the Genera Conus and Cypraea of the Class Gastropoda. Bull. Amer. Mus. nat. Hist., Vol. 103, Art. 1.*

By Henry Dodge. American Museum of Natural History, New York. $1.75 (paper). 134 pp. 1953.

This is the second instalment of a work, the first instalment of which has already been reviewed (*Q.R.B.*, 28: 302. 1953). The present instalment covers the Cephalopoda, and the genera *Cypraea* and *Conus*. The maintenance of the high standard set by the author in the first instalment will be equally helpful to all those systematic malacologists who from time to time are compelled to dip into that rather dry and deadly and frequently sterile field of systematic nomenclature.

It is disappointing to find no information at all as to

where the sage of Uppsala obtained the type material of *Conus princeps*. Most of the Pacific American mollusca in the *Systema Naturae* are circumpolar species, originally named and described from European examples, but this cone is found only in the Gulf of California and the neighboring Pacific coast of Mexico. From whom did Linnaeus obtain his material? Was it from his disciple Loeffler, who made the Spanish Empire his field and who died on the Spanish Main? Or was it from Venegas, the pioneer Jesuit naturalist of Baja California, who seems to have been familiar with all the work of his great Swedish contemporary? Or were these shores visited by another naturalist prior to 1758, someone whose name has since passed out of history?

JOSHUA L. BAILY, JR.

TRAITÉ DE ZOOLOGIE—*Anatomie, Systématique, Biologie. Volume X, Fascicules I and II—Insectes Supérieurs et Hémiptéroïdes.*

By A. Badonnel and 10 other contributors; edited by Pierre-P. Grassé. Masson et Cie., Paris. 13,000 fr. I: Pp. 1–975 + 5 pl.; text ill. II: Pp. 976–1948 + 1 pl.; text ill. 1951.

Whether all of those who hopefully turn for information to these impressive fascicles of Grassé's treatise will truly find the enlightenment they seek is doubtful, but it is hardly likely that anyone will close the covers of these beautiful books without first having gained considerable enjoyment—perhaps even the desire to own them despite their shortcomings. In this sorry era of scientific publication, characterized by numerous costly books, often of unlovely composition, poor craftsmanship, and substandard materials, these volumes come as pleasant reminders of the publisher's art that seems now dormant.

Fascicle I is devoted to the Megaloptera, Raphidiodea, and Neuroptera (by Berland and Grassé), Mecoptera (Grassé), Trichoptera (Despax), Lepidoptera (Bourgogne), Diptera and Siphonaptera (Séguy), and concludes with the non-aculeate Hymenoptera (Berland and Bernard). Fascicle II completes the order Hymenoptera (Berland, Grassé, and Bernard; also an account of formicine-feeding biology by le Masne), passing thereafter to the Strepsiptera (Jeannel), Corrodentia (Badonnel), Mallophaga and Anoplura (Séguy), Homoptera (Pesson), Heteroptera (Poisson), and Thysanoptera (Pesson), concluding with a joint subject-illustration index of 70 pages, and an 8-page synoptic table of contents to the whole volume. A glance at the authorship foretells the strength of the text: the Diptera, Hymenoptera in part, Corrodentia, Homoptera, and Heteroptera are best treated.

In general, each order tends to be dealt with in the same way, and each topic is ordinarily illustrated by admirably chosen, cleanly executed line drawings or sketches. There is first a brief account of the definitive and general ordinal characters, and then a more or less detailed account of the external and internal gross anatomy of the adult insect, followed by a similar treatment of larval anatomy. Larval life, reproduction, some aspects of natural history, and distribution are then discussed, and a brief review given of the major systematic categories within the order—often to subfamily. Even though a special volume of the treatise is promised on the anatomy, physiology, and reproduction of insects in general, the scattered comments concerning one or another aspect of insect physiology, biochemistry, cytology, or genetics lend very little of value to this work, and much more might justifiably be expected in the way of adequate coverage and résumé in a modern monograph such as this one. Indeed this is the basis for an over-all criticism: the topics touched upon range too widely for most authors, however profound their own research within more limited domains, and the result is an uneven patchwork of varying orders of scholarship.

Within each section an author may give extended treatment to topics of personal interest or familiarity (e.g., Bourgogne's account of the reproductive anatomy of the Lepidoptera; Pesson's description of the anatomy of the homopterous head and mouthparts; etc.), and these excellent accounts of limited subjects show what might have been accomplished had a galaxy of specialists been invited to synthesize these volumes. On the whole, however, for most orders the information is by and large disappointingly superficial. The bibliographies do not improve matters greatly, for in few cases are they themselves outstanding guides to the relevant literature, and unfortunately also their works are very seldom cited in the text.

Too much, perhaps, has been attempted in these volumes; too often the concern is with the works and insects "de notre pays." But these books are wonderfully and beautifully illustrated, their text does have its strong points, and they will find a useful, if not indispensable, place in the biologist's library even if the works of Sharp, Schröder, Kükenthal and Krumbach, and Weber are at hand.

K. W. COOPER

A CHECK LIST OF THE GENERA AND SPECIES OF MALLOPHAGA.

By G. H. E. Hopkins and Theresa Clay. The British Museum (Natural History), London. £2. vi + 362 pp. 1952.

A new and up-to-date checklist of the biting lice has long been needed. The latest, and until now the only, list was that by L. Harrison, which appeared in 1916. Since that date there has been much activity among the workers in this group of insects.

Hopkins and Clay have worked over all the names

which have been proposed for the Mallophaga, endeavoring to weed out homonyms and nomina nuda and to determine generic and specific synonymy. In the introductory chapter, a discussion of the *International Rules of Zoological Nomenclature* is given, pointing out that often in the past workers have not followed, or have misinterpreted, these rules. It seems that the present authors are, in one or two instances, themselves guilty of the latter sin.

The body of the book is the strictly alphabetical list of the accepted genera, each with its list of accepted species. Synonymy, genotypes, and bibliographic citations are given. Type host, so far as it can be determined, and reference to the original description, are given for each trivial name. There is much new synonymy, both generic and specific. The work is certainly a great advance over that of Harrison.

EDWARD A. CHAPIN

A GENERIC REVISION OF THE FAMILY AGROMYZIDAE (DIPTERA) WITH A CATALOGUE OF NEW WORLD SPECIES. *Univ. Calif. Publ. Entom., Vol. 8, No. 8.*

By Kenneth E. Frick. University of California Press, Berkeley and Los Angeles. $1.25 (paper). Pp. 339–452; ill. 1952.

The agromyzids are divided into two subfamilies, Agromyzinae and Phytomyzinae, which the author considers to contain 4 and 15 genera, respectively. In a series of keys, Frick has shown how the male terminalia and certain other adult and larval structures are generically correlated. These form the basis of the proposed generic concepts. Accompanying the generic keys and catalogue are comprehensive sections on the distribution, the economic importance of the family, the morphology of the adults and larvae, a historical background, and the relationship of this family to related acalyptratae.

A list of 270 generic and specific names, as previously known, side by side with the author's concepts, will undoubtedly be of considerable aid to students of this group. Twelve pages of cited literature and 34 clearly drawn illustrations complete this ambitious contribution.

FRED M. SNYDER

THE HELEIDAE OF CALIFORNIA. *Univ. Calif. Publ. Entom., Vol. 9, No. 2.*

By Willis W. Wirth. University of California Press, Berkeley and Los Angeles. $2.00 (paper). iv + pp. 95–266; ill. 1952.

In this paper, the author has treated the "no-see'ums" and related species found in California. Besides keys, and detailed and complete specific descriptions and synonymies of the 110 species, sections are also included on the morphology and economics of the group, as well as a key for identification of larvae to genus. Detailed drawings of the male genitalia and antennal segments, as well as thoracic patterns, accompany most of the descriptions. This is a pleasant departure from many keys or treatments of faunal regions in which only one sex is used for the first couplet in a key, and the following couplets are based on characters found in the opposite sex. Wirth's excellent paper should enable interested students to identify the California species without having to consult other papers, providing proper optical equipment and properly prepared specimens of these minute midges are available.

FRED M. SNYDER

THE HORSE-FLIES (DIPTERA: TABANIDAE) OF THE ETHIOPIAN REGION. *Vol. I: Haematopota and Hippocentrum.*

By H. Oldroyd. British Museum (Natural History), London. £2. x + 225 pp. + 25 pl.; text ill. 1952.

This is the first of 3 proposed volumes which will eventually treat the Tabanidae of the Ethiopian region. Comprehensive sections on their structure, phylogeny, classification, biology of early stages, and relationship to disease precede Oldroyd's characteristically concise descriptions of the 174 species of *Haematopota* and *Hippocentrum* treated in this volume.

Specific identifications in *Haematopota* are notoriously difficult because of the lack of easily described morphological characters and the dependence which must be placed on somewhat intangible wing patterns. This situation has been admirably circumvented by copious line drawings of the frons and antennae, and photographs of wings of all except one or two of the species treated. This large genus is divided into 11 species-groups, and 4 subgroups which are adequately keyed. Maps showing the distribution of the groups or subgroups are presented, and more detailed information is found after the discussion of each species.

Oldroyd's is the first complete key to the *Haematopota* of the Ethiopian region, and the complete synonymy and valuable notes which follow his descriptions make this paper a prerequiste for any serious study of this group.

A review of this volume would be incomplete without an appreciative mention of the author's dry humor, which is especially apparent in the introductory portions of the paper, and which greatly aids in a sympathetic understanding of the many problems involved in defining specific limits in this difficult group of horse-flies. This series of volumes, when completed, will undoubtedly become a classic treatment of the group, and remain so for many years.

FRED M. SNYDER

THE TRICHOPTERA (CADDIS-FLIES) OF AUSTRALIA AND NEW ZEALAND.

Described and figured by Martin E. Mosely and D. E. Kimmins. British Museum (Natural History), London. £4. 10s. 0d. iv + 550 pp.; ill. 1953.

This monumental work was commenced by the authors in the years just preceding the Second World War and was about half done when the war made it necessary for them to suspend their studies. Later, work was resumed and again interrupted by the death of the senior author. Finally, Kimmins completed the manuscript for publication, which resulted after the Australian and New Zealand governments made generous contributions toward the costs.

In the course of the work it was necessary to describe 23 new genera and 113 new species, thereby raising the total numbers of known genera and species for this region to 90 and 261, respectively. Of these, 177 species in 69 genera are Australian. Keys to families, genera, and species are given, and most of the species are illustrated by line drawings of the wings and male terminalia.

EDWARD A. CHAPIN

A CATALOGUE OF THE AMERICAN HESPERIIDAE *Indicating the Classification and Nomenclature adopted in the British Museum (Natural History). Part II (Groups B, C, D) Pyrginae, Section I.*

By Brigadier W. H. Evans. The British Museum (Natural History) London. 30s. (paper). v + 178 pp. + 16 pl. 1952.

The second part (Part I, see *Q.R.B.*, 26: 75. 1951) of Brigadier Evans' monumental work on the Hesperiidae (Skippers) of the New World covers the first of the two sections into which the author divides the subfamily Pyrginae. Recognized as valid are 42 genera, 307 species, and 173 subspecies. Of these, 4 genera, 45 species, and 66 subspecies are named as new. All of these but 6 species are represented in the British Museum. Placed in synonomy are the names of 37 genera and 313 species and subspecies. The text is arranged in the form of a greatly expanded key, so that diagnostic characters are given for all genera, species, and subspecies. The following essential taxonomic information is given: the names, authorities, and dates of fixation of all generic names; the authorships and dates of description of all names; the authorships and publication dates of the chief published figures of all trivial names; the type localities of all trivial names, including those placed as synonyms; and line drawings of the important parts of the genitalia of nearly all of the species. When the types of trivial names are in the British Museum this is stated; and the localities of all British Museum specimens are given.

No bibliographic citations are given other than a very short list of the chief works on the fauna, although, as the author states, the name of the author and the date of publication will facilitate finding the original references. It is unfortunate that the locations of types not in the British Museum are not given, even when these are known; and that the distributional data are based solely on British Museum specimens, even when a species or subspecies is well known from additional localities. I also note with sorrow that some misspelling of scientific names (such as *corusis* for *confusis*, which will certainly compound corusion) has crept into the text. The relatively minor nature of such criticisms, however, only serves to emphasize the enormous contribution to taxonomy which this work represents. Other parts dealing with the remainder of the New World Hesperiidae are expected to follow.

The feature of this work most significant to biologists in general is the considerable expansion of the subspecific category. In this respect the classification of the Hesperiidae has lagged behind that of other groups of the diurnal Lepidoptera, due in part to scarcity of material and to a considerable conservatism of the students of the group, and in part to an apparent conservatism of the Hesperiidae themselves in forming geographic subspecies. The author has made an excellent beginning in this respect—one that will serve as a sound basis for future geographic analyses.

ALEXANDER B. KLOTS

AUSTRALIAN TERMITES. *The Biology, Recognition, and Economic Importance of the Common Species.*

By F. N. Ratcliffe, F. J. Gay, and T. Greaves. Commonwealth Scientific and Industrial Research Organization, Melbourne; [Tait Book Company, Melbourne]. £15 2s. 0d. 124 pp.; ill. 1952.

This volume is a manual for use by householders, builders, architects, and pest-control operators who need information on this important subject, but to whom the information in Hill's highly technical *Termites (Isoptera) from the Australian Region* is not available. The first half of the work is devoted to a readable account of termites—their habits, general biology, and economic importance. Discussion of the 12 known genera and the more commonly encountered species makes up the second half. The illustrations are well selected and reproduced; they are partly line drawings of anatomical structures and partly half-tones from photographs of nest sites.

EDWARD A. CHAPIN

NOTES ON BRITISH ICHNEUMONINAE WITH DESCRIPTIONS OF NEW SPECIES (HYM., ICHNEUMONIDAE). *Bull. Brit. Mus. (Nat. Hist.) Entom., Vol. 3, No. 4.*

By J. F. Perkins. The British Museum (Natural History) London. 15s. (paper). Pp. 103–976; ill. 1953.

Preparatory to the publication of a handbook on the British species, this assemblage of notes on the Linnaean, Stephens, and Desvignes types, as well as on the ichneumonine types of the Bridgman, Marshall, Morley, and Carr collections, and other material, places the faunal list of British Ichneumoninae in good taxonomic order. Three new names are proposed, and 2 genera and 16 species of Ichneumoninae are newly described. A list of the British Ichneumoninae (332 species) is given that markedly departs from the Kloet and Hincks (1945) check list, for no less than 110 names are removed from the latter list of species, and 105 are added.

K. W. Cooper

The Formicidae of Australia. *Volume I. Subfamily Myrmeciinae.*

By John Clark. Commonwealth Scientific and Industrial Research Organization, Melbourne; [Tait Book Company, Melbourne]. 25s. 230 pp.; ill. 1951.

This, the first volume of a projected monograph on the ants of Australia, treats of the primitive subfamily Myrmeciinae, which contains the two genera *Myrmecia* and *Promyrmecia*. The first of these genera includes the large and vicious "bull dog ants," some species of which reach a length of 1½ inches. The members of the other genus are smaller and are known as "jumpers" from their mode of progression by short jumps. Somewhat over a hundred Australian species (21 of which are new here) are considered to belong to this subfamily. Each species is fully described, and most are illustrated by line drawings showing dorsal and lateral views. Keys are given to the Australian subfamilies of ants, to the two genera, and to the included species.

Edward A. Chapin

The Social Insects.

By O. W. Richards. MacDonald, London; Philosophical Library, New York. $4.75. 219 pp. + 21 pl.; text ill. 1953.

A readable summary of this absorbing subject, illustrated by some of the best insect photographs, will do much to inform the general public on the ways of social insects. For the beginner, an initial chapter tells how insects are constructed and operate, and develops an understanding of instinctive behavior by proceeding from relatively simple nest-building to complex interactions between individuals. Wasps are shown to include all intergrades between the solitary and fully social extremes, and the problem of the origin of a worker caste is raised but not solved. Solitary and social bees repeat the pattern, while ant and termite societies require more detailed study. Probably it is a Britishism to refer to driver and legionary ants where North Americans are more prone to use the term "army ant." Since neither army ant nor the genus *Eciton* is given the term familiar in this country, Schneirla's work appears suddenly. But the subject is handled in such a cosmopolitan way, with African examples included as well as those of Central and South America, that in such a short book, the omission is not serious. Richards clearly hopes to stimulate further study of social insects and notes that "a beehive or an ant-colony is easier to keep than a dog, and although it will hardly be so satisfying to the affections, it will provide a host of unsolved problems on which anyone may exercise his disinterested curiosity. It is the application of this distinctively human faculty, not only to insect societies but also to our own, which is most needed in the world to-day."

Lorus J. & Margery J. Milne

Instructions for Collectors. No. 3. Reptiles, Amphibians and Fishes. *Sixth Edition.*

British Museum (Natural History), London. 9d. (paper). 28 pp.; ill. 1953.

This is a concisely written little pamphlet with a considerable amount of information about the various phases of the collecting, preserving, and shipping of cold-blooded vertebrates. Rather full consideration is given to fixatives and preservatives. Although formalin and ethyl alcohol are discussed in some detail, no mention is made of isopropyl alcohol, which now is being used in increasing amounts in a number of American museums. In addition to collectors, for whom it was intended, this booklet, or a counterpart, should also be in the hands of those responsible for maintaining ichthyological and herpetological collections.

Arnold B. Grobman

Fishes of the Marshall and Marianas Islands. *Volume I. Families from Asymmetrontidae through Siganidae. Bulletin 202.*

By Leonard P. Schultz and Collaborators: Earl S. Herald, Ernest A. Lachner, Arthur D. Welander, and Loren P. Woods. Smithsonian Institution, U. S. National Museum, Washington. $2.75 (paper). xxxii + 685 pp. + 74 pl.; text ill. 1953.

This very tangible contribution to ichthyology is one of the fruits of the scientific work that preceded and followed the atom-bomb tests of Operation Crossroads. It brings a not inconsiderable section of the vast Indo-Pacific fish fauna into the light of modern, and, in so far as material and time allowed, critical and precise

systematic analysis. With the aid of four collaborating ichthyologists Schultz is providing, in this volume and another in preparation, a thorough digest of the fishes of two of the main island groups of the central Pacific. Where sufficient need and opportunity existed, the authors expanded their material to include larger areas of the Pacific, thus vastly augmenting the usefulness of the treatise. The treatment, in consequence, is not uniform, but the authors have wisely refrained from attempting any coverage broader than that justified by their own researches. They have thus avoided the piling of confusion on doubt, such as has featured most of the published work on the Indo-Pacific fauna.

Schultz has already published *The Biology of Bikini Atoll, with Special Reference to the Fishes*, but in this volume, except for fragments scattered through the maze of systematic detail, generalizations are confined to a single-page account of General Faunal Relationships. In this section it is indicated that varying degrees of differentiation have been shown to exist between populations of wide-ranging species in the tropical Indo-Pacific, and that specific and subspecific endemism characterizes the fish faunas of the Hawaiian Islands, most notably, and also Polynesia and Micronesia, the Indo-Australian region and Melanesia, and the area from Mauritius to the Red Sea. It is to be hoped that these speciational considerations will be treated synthetically in the next volume or in a separate paper. A cursory examination of the volume now published discloses little clear-cut evidence on local differentiation except among the relatively sedentary Syngnathidae and Atherinidae and in *Acanthurus triostegus* (with *sandvicensis*). The wide distribution of the multitudinous species through at least much of the Indo-Pacific area still appears to characterize the main elements of the fauna.

One unhappy action, in my opinion, was the adoption of the Stenzel system of group endings for suborders, orders, and superorders. The approval by the American Society of Ichthyologists and Herpetologists of this system, invitingly attractive on first examination, has now been emphatically repudiated.

CARL L. HUBBS

BIRDS OF MEXICO. *A Guide for Field Identification. By Emmet Reid Blake; illustrated by Douglas E. Tibbitts. The University of Chicago Press, Chicago.* $6.00. xxx + 644 pp. + 1 pl.; text ill. 1953.

The output of material on Mexican birds has been increasing in tempo during recent years. Most of the work has been of a taxonomic or distributional nature intended primarily for the professional student. Now, as a result of these preliminary investigations, we have a handbook which is intended to facilitate bird recognition in the field by all and sundry bird enthusiasts. This is indeed a welcome publication for American bird students, as many of them have been or are thinking of going to Mexico for new bird adventures. Up to now, no non-technical publication, outside of Sutton's *Mexican Birds, First Impressions*, has been available and this is not in any sense a field guide but rather serves as a useful and important introduction to the Mexican avifauna.

Almost a thousand species occur within the political confines of Mexico, and this fact is reflected in the total of 644 pages that comprise this book. The species are arranged in phylogenetic order, an arrangement which implies that the user has some previous knowledge of birds. Each species has a general description of both sexes, its distribution, a list of geographic races, and miscellaneous remarks that usually emphasize recognition characteristics. Each family has a key, based primarily on color characteristics, to its various Mexican members. Again, this means that the observer first has to be able to identify his bird to the correct family, or else go thumbing through the book looking for pictures.

Except for the Collared Aracari there are no color plates—all illustrations are pen and ink. Over 300 birds are illustrated and it would therefore seem ungrateful to complain about the pictures. Yet the fact remains that many species are described only in writing. My suggestion for improvement would be a color plate here and there that would depict some of the more difficult groups, such as the humming-birds. To cut down on expense I would then eliminate such birds as the Red-eyed Vireo and Northern Waterthrush and others that are illustrated in existing North American handbooks. More side-by-side comparisons, such as was done with the orioles, would have been more instructive. A friend of mine now living in Mexico and using the book has suggested that local Mexican names would be useful. My limited experience with Mexican birds makes me feel presumptuous to express the feeling that some of the distinguishing characteristics described are perhaps better for separating birds in the hand than in the bush. But the latter criticism is one that can be remedied only by continual field work and the cooperation of observers who pool their experiences.

The writer has done a good job with a difficult task and will certainly earn the gratitude of bird students. I dare say that this book may even provide a decided impetus to North American students to visit their sister republic. It goes without saying that so much has to be learned about the life history of all Mexican forms that almost any observation there can become a welcome contribution to ornithology. The printing is well executed and the paper of good quality, so that the book will certainly withstand considerable usage. We are happy to mention the presence of maps on the insides of both covers. The price is certainly reasonable. I therefore predict that this book will become an important adjunct to all Mexico-bound naturalists.

[Note to those concerned: Why not charge an extra dollar or so and add some color plates?]

HENRI C. SEIBERT

GENERA AND SUBGENERA OF RECENT MAMMALS, *A list of the Names Proposed for Genera and Subgenera of Recent Mammals from the publication of T. S. Palmer's "Index Generum Mammalium" 1904 to the end of 1951.*

By L. R. Conisbee. British Museum (Natural History), London. £1. 0s. 0d. ii + 109 pp. 1953.

It is one of the burdens of systematic zoology and botany that systematics must deal with lists of genera and of species without much indication (to the general reader) of what they are, and that such lists require the supplement of lists of names as such. Every practicing taxonomist must have within reach one or more of the published lists of generic names if he is himself engaged in naming new forms, and we are fortunate to have available Neave's *Nomenclator Zoologicus*, a list of the animal genera, now brought up to 1950.

Among more special lists one of the most useful has been Palmer's list of mammalian genera. It is gratifying to have this brought up to date by a supplementary list that retains Palmer's excellent form. The thoroughness of the new list is attested by the number of names (35) it contains that are not listed by Neave. The alphabetic list is supplemented by one in which the genera and subgenera are arranged according to orders and families.

KARL P. SCHMIDT

THE MAMMALS OF MINNESOTA. *Occasional Papers: Number 6. Paper No. 2869, Scientific Journal Series, Minnesota Agricultural Experiment Station. Minnesota Museum of Natural History, University of Minnesota.*

By Harvey L. Gunderson and James R. Beer. The University of Minnesota Press, Minneapolis. $3.50 (cloth); $2.50 (paper). xii + 190 pp.; ill. 1953.

This semipopular account of the Minnesota fauna is a successor to the works of Herrick, Surber, Swanson, and Roberts, which are out of print. The layout of the book follows the usual style, with discussions of mammal study techniques and of the geography of Minnesota preceding the systematic accounts. There are keys to the species in each order, but subspecies are generally avoided as being of little interest to the intended reader. To the mammalogist, the most useful material will be the distribution map which accompanies each species description and which indicates all authentic records. To the layman, the readily understood descriptions and notes on behavior will make this a fine reference handbook. The keys may prove hard going to the amateur, but it is difficult to see how technical terminology could be any further simplified without rendering it meaningless. The book should prove a useful addition to the library of the Minnesota naturalist, and to interested mammalogists everywhere.

BRYAN P. GLASS

A SYNOPSIS OF THE NORTH AMERICAN MICROTINE RODENTS.

By E. Raymond Hall and E. Lendell Cockrum. University of Kansas Publications, Museum of Natural History, Lawrence. Free upon request (paper). Pp. 375–498; ill. 1953.

The subfamily Microtinae is notorious for the difficulty that it presents to the taxonomist, and mammalogists should welcome this latest and most complete review of this group of North American rodents. The authors have consolidated and analyzed taxonomic information formerly available only in numerous scattered publications ranging in age up to more than fifty years. In text and maps each genus is diagnosed and its known range is outlined. Specific locations on maps are limited to marginal records, a device that should prove helpful in determining future range extensions.

The treatment is conservative, as evidenced by the authors' retention of *Lagurus* as the valid name for the sagebrush voles, and inclusion of *Pilymys* as a subgenus of *Microtus*. In general, they have followed the modern trend toward reducing the number of full species and increasing the number of subspecies. Their treatment of isolated populations, both insular and continental, is variable. Some insular forms are retained as separate from closely related mainland species (e.g., *Clethrionomys albiventer* from *C. rutilus*), while others (e.g., the various forms of *Microtus oeconomus*) are all recognized as subspecies. On the mainland, various isolated continental forms are regarded as subspecies (e.g., some forms of *Microtus longicaudus*), while others are regarded as separate species (e.g., *Microtus parvulus* and *M. pinetorum*). Doubtless there are quite justifiable taxonomic grounds for these stands, but the basis for them is not explained in the text.

As a manual for identifying American voles and lemmings, this volume should be the standard for many years to come.

BRYAN P. GLASS

GUIDE FOR THE IDENTIFICATION AND REPORTING OF STRANDED WHALES, DOLPHINS, PORPOISES AND TURTLES ON THE BRITISH COASTS. *Second Edition.*

By F. C. Fraser and H. W. Parker. British Museum (Natural History), London. 2s. (paper). viii + 42 pp.; ill. 1953.

Because of the long coast lines of the British Isles, there are frequent opportunities for the observation of stranded whales, dolphins, porpoises and turtles. To assemble data and specimens, the British Museum

began to encourage the systematic reporting of the cetaceans in 1913, and of the turtles in 1939. In 1949, information of interest to potential informants, previously published in separate leaflets, was assembled in a single pamphlet. The booklet under review is the second edition of this interesting and useful work.

It begins with a few pages of general information, followed by a key to the cetacenas known, or expected, along the British Coasts. Each of 24 species is then described and illustrated. A similar but shorter section treats five species of sea turtles.

The publication is thoughtfully conceived and nicely executed. Although primarily designed for a layman who might come across a stranded cetacean or turtle on a British Coast, and who might wish to pass on to the British Museum the details of his discovery, the pamphlet will interest a larger audience. Within its scope (morphological descriptions of some 30 forms of air-breathing marine vertebrates) it is a very sound summary that should be informative to many biologists far from the coasts of the British Isles.

ARNOLD B. GROBMAN

FORAMINIFERA ECOLOGY OFF PORTSMOUTH, NEW HAMPSHIRE. FORAMINIFERA SPECIES OFF PORTSMOUTH, NEW HAMPSHIRE. *Bull. Mus. Comp. Zool. Harvard Coll., Vol. 106, Nos. 8 and 9.*

(8) By Fred B Phleger. (9) By Frances L. Parker. Museum of Comparative Zoölogy, Harvard College, Cambridge. $2.50 (paper). Pp. 315–423 + 6 pl.; text ill. 1952.

FORAMINIFERAL DISTRIBUTION IN THE LONG ISLAND SOUND—BUZZARDS BAY AREA. *Bull. Mus. Comp. Zool., Harvard Coll., Vol. 106, No. 10.*

By Frances L. Parker. Museum of Comparative Zoölogy, Harvard College, Cambridge. $1.10 (paper). Pp. 428–473 + 5 pl. 1952.

HYDROMEDUSAE. *Great Barrier Reef Expedition 1928–29, Scientific Reports, Vol. VI, No. 4.*

By P. L. Kramp. British Museum (Natural History), London. £1. 0. 0. (paper). Pp. 258–322 + 2 pl.; text ill. 1953.

VARIATION IN SOME UNARMED HYMENOLEPIDIDAE (CESTODA) FROM RODENTS. *Univ. Calif. Publ. Zool., Vol. 57, No. 1.*

By Marietta Voge. University of California Press, Berkeley and Los Angeles. 75 cents (paper). 52 pp.; ill. 1952.

ISOPODA. *Families Cymothoidae and Serolidae. B.A.N.Z. Antarctic Research Expedition 1929–1931 Under the Command of Sir Douglas Mawson. Reports —Series B (Zoology and Botany), Vol. VI, Part 2.*

By Herbert M. Hale. The B.A.N.Z.A.R. Expedition Committee, Adelaide; issued through the Barr Smith Library, University of Adelaide. 10s. (paper). Pp. 21–36; ill. 1952.

CONTRIBUTIONS TO THE MORPHOLOGY AND TAXONOMY OF THE BRANCHIOPODA NOTOSTRACA, WITH SPECIAL REFERENCE TO THE NORTH AMERICAN SPECIES. *Proc. U. S. Natl. Mus., Vol. 102, No. 3291.*

By Folke Linder. Smithsonian Institution, Washington. Free upon request (paper). 69 pp. + 7 pl.; text ill. 1952.

THE APSEUDID CHELIFERA OF THE EASTERN TROPICAL AND NORTH TEMPERATE PACIFIC OCEAN. *Bull. Mus. Comp. Zool., Vol. 107, No. 9.*

By Robert James Menzies. Museum of Comparative Zoölogy, Harvard College, Cambridge. $1.00 (paper). Pp. 443–496; ill. 1953.

NEW AND LITTLE KNOWN FALSE SCORPIONS (ARACHNIDA, CHELONETHIDA) FROM MONTEREY COUNTY, CALIFORNIA. *Bull. Amer. Mus. Nat. Hist., Vol. 99, Article 4.*

By Joseph C. Chamberlin. American Museum of Natural History, New York. 75 cents (paper). Pp. 259–312 + 2 pl.; text ill. 1952.

THE SUB-GENUS STEGOMYIA (DIPTERA: CULICIDAE) IN THE ETHIOPIAN REGION. *II. Distribution of Species Confined to the East and South African Sub-Region. Bull. Brit. Mus. (Nat. Hist.) Entomology, Vol. 3, No. 1.*

By P. F. Mattingly. The British Museum (Natural History), London. 15s. (paper). 65 pp.; ill. 1953.

THE NEOTROPICAL GENERA PROCORNITERMES AND CORNITERMES (ISOPTERA, TERMITIDAE). *Bull. Amer. Mus. Nat. Hist., Vol. 99, Art. 8.*

By Alfred E. Emerson. American Museum of Natural History, New York. 80 cents (paper). Pp. 479–539; ill. 1952.

NEW AND LITTLE KNOWN SHARKS FROM THE ATLANTIC AND FROM THE GULF OF MEXICO. *Bull. Mus. Comp. Zool., Vol. 109, No. 3.*

By Henry B. Bigelow, William C. Schroeder, and Stewart Springer. Museum of Comparative Zoölogy, Harvard College, Cambridge. $1.10 (paper). Pp. 213–276; ill. 1953.

A REVISION OF THE FAMILY EMBIOTOCIDAE (THE SURFPERCHES). *Fish Bull. No. 88.*

By Fred Harald Tarp. State of California, Dept. of Fish and Game, Bureau of Marine Fisheries, San Pedro. Free (paper). 99 pp.; ill. 1952.

REPORT ON THE MCCABE COLLECTION OF BRITISH COLUMBIAN BIRDS *Bull. Mus. Comp. Zool., Vol. 109, No. 2.*

By J. C. Dickson, Jr. Museum of Comparative Zoölogy at Harvard College, Cambridge. $1.75 (paper). Pp. 123–209 + 1 pl. 1953.

ZOOLOGICAL RESULTS OF A FIFTH EXPEDITION TO EAST AFRICA. II. *Birds From Nyasaland And Tete. Bull. Mus. Comp. Zool., Vol. 110, No. 2.*

By J. L. Peters and A. Loveridge. Museum of Comparative Zoölogy at Harvard College, Cambridge. 75 cents (paper). Pp. 87–139 + 2 pl. 1953.

ECONOMIC ZOOLOGY

CHEMICAL CONTROL OF INSECTS.

By T. F. West, J. Eliot Hardy, and J. H. Ford. John Wiley & Sons, New York. $3.25. xi + 211 pp.; ill. 1952.

The 3 authors herein attempt to present the more important insecticides in use at the present time and the methods of using them. Throughout this volume they have also given the structural formulae for the major insecticides and have considered their chemistry briefly. After discussing the use of aeroplanes and helicopters together with other methods of application of insecticides, the characteristics and behavior of insects are treated briefly and an outline of the various methods of insect control is presented. Succeeding chapters discuss fumigation with the more practical and common chemicals, the use of nicotine and related compounds, rotenone and related compounds, the arsenicals, petroleum oils, coal tar derivatives—especially the dinitro compounds—and some miscellaneous insecticides including the organic phosphates, azobenzene, ryanex, and the fluorine and sulfur compounds. Soil insecticides are discussed separately. A chapter is devoted to the insecticidal properties and uses of each of these materials, pyrethrum, lethane and thanite, and chlorinated persistent insecticides including a special discussion of DDT and its analogues. A short consideration of insect repellants and attractants is accompanied by a chapter devoted to the important subject of weed control. This volume presents a brief and up-to-date survey of the major chemical materials which are now being used as methods of insect control.

DWIGHT M. DELONG

DDT AND NEWER PERSISTENT INSECTICIDES.

By T. F. West and G. A. Campbell. Chemical Publishing Company, New York. $8.50. xiv + 632 pp. + 14 pl.; text ill. 1952.

This volume deals with the history and development of chlorinated hydrocarbon insecticides, a process initiated by the realization of the potential possibilities of this group of compounds after the discovery of the insecticidal properties of DDT. A brief history of the discovery and development of DDT is presented, with an account of its important use as a control for the vectors of typhus fever in Italy during 1944. There is complete and detailed discussion of the early research work at Basle and the subsequent manufacture and the chemistry of DDT. The latter includes the various physical and chemical properties of DDT, its volatility, solubility, etc., and an extensive table of all the known analogues together with their structural formulae and other data. Following this, the authors discuss the principles of formulation, the toxic manifestations of DDT, and its various uses in combination with paint, textiles, and paper. Its toxicity to various animals other than insects and its relation to human health are briefly discussed. Some 285 pages are devoted to a discussion of the toxicity and use of DDT against various types of insects, including those affecting man directly, household pests, arboreal and agricultural insects, and beneficial species. A smaller portion of the volume is devoted to benzine hexachloride, chlordane, toxaphene, and other related compounds. This volume is well indexed and contains an extensive bibliography. It is to date one of the best and most complete discussions of DDT as an insecticide.

DWIGHT M. DELONG

WILDLIFE MANAGEMENT. *Volume II. Fur Bearers, Waterfowl, and Fish.*

By Reuben Edwin Trippensee. McGraw-Hill Book Company, New York, Toronto, and London. $7.50. xii + 572 pp.; ill. 1953.

Where the first volume of this series (*Q.R.B.*, 24: 368. 1949) dealt with management of uplands and upland game, the prime consideration of the second volume is water: water, and the species that live in or near it, furbearers, waterfowl, and fish.

The book is divided into four parts, the first of which deals with the basic ingredient itself, water and its conservation. The evils of municipal and industrial pollution, soil erosion, floods, unwise lumbering, etc., are reviewed in the light of their effect on the continued adequate supply of clean water for streams, rivers, swamps, and marshes. Here is the one resource on which the enterprises discussed in the rest of the book depend, and here the author achieves a higher philosophical plane than in later chapters.

Parts 2, 3, and 4 deal with furbearers, waterfowl, and fish, respectively. A brief discussion of the fur trade precedes the accounts of individual furbearing species, each of which closes with recommendations for management. For waterfowl the management procedures are summed up in a chapter contributed by Ira W. Gabrielson, and there is a similar arrangement for cold-water fish, contributed by C. M. Tarzwell, and for warm-water fish, by R. W. Eschmeyer. There is also a chapter on farm fish ponds, by Louis A. Krumholz. Several others contributed sections that deal with regional waterfowl ecology.

The life histories of furbearers, waterfowl, and game fish are treated in condensed but comprehensive detail, so that this part of the text is quite encyclopedic in nature and should be a useful reference on the natural history of water-loving game. Not least important are the special bibliographies at the close of each chapter, and the general references listed at the end of the book.

BRYAN P. GLASS

CULTURE AND DISEASES OF GAME FISHES.

By H. S. Davis. University of California Press, Berkeley and Los Angeles. $5.00. x + 332 pp.; ill. 1953.

It has been fifty years since the last comprehensive manual of fish culture was published in this country, and the most significant change, as the author says, is the shift in emphasis from the simple idea of hatching fish to rearing them to suitable sizes as part of an integrated management program. Hence our hatcheries are concerned now with problems of nutrition and diseases that were undreamed of half a century ago. As its title indicates, this book is concerned with two closely related subjects, each of which might have occupied a volume by itself, and they are treated in separate halves of the book. This is actually a much expanded version of the author's bulletin, *Care and Diseases of Trout*, and it would seem that his interest is still with trout, for the whole series of chapters dealing with spiny-rayed fishes lacks the detail provided in the trout chapters. Even more significantly, these chapters are without a single illustration. Indeed, the whole book is sparsely illustrated. Inasmuch as it appears to be intended as a textbook in fisheries courses, as well as a practical manual, it is unfortunate that the problems of fishpond productivity and economics were not discussed in more detail, although the author is obviously aware of the less tangible aspects of the farm fishpond.

This should nevertheless be a useful introductory text as well as a reference book for workers in hatcheries (even though the paucity of subheadings makes a quick searching of topics difficult).

The second half of the book, given over to diseases of game fishes, and written out of extensive personal knowledge, is a valuable summary of material previously available only in a scattered literature. It should be noted however, that this literature is almost exclusively North American. There are several appendices, concerned with such technical matters as the construction of drip incubators, the culture of daphnia, and the like. It is probably this section to which practical hatchery men will offer most additions for future editions. I myself would like to see a chapter or two devoted to reviewing foreign experience and knowledge where it concerns the same species cultured in North America.

JOEL W. HEDGPETH

AGE, GROWTH, AND PRODUCTION OF YELLOW PERCH IN LAKE ERIE. *Fishery Bull. 70, Vol. 52.*

By Frank W. Jobes. U. S. Department of the Interior, Fish and Wildlife Service, Washington; [U. S. Government Printing Office]. 20 cents (paper). ii + pp. 205–266; ill. 1952.

CALIFORNIA COOPERATIVE SARDINE RESEARCH PROGRAM. *Progress Report 1 January 1951 to 30 June 1952.*

State of California, Department of Fish and Game, Marine Research Committee, Los Altos. Free (paper). 51 pp.; ill. 1952.

POULTRY BREEDING. *Third Edition.*

By Morley A. Jull. John Wiley & Sons, New York; Chapman and Hall, London. $6.00. vii + 398 pp.; ill. 1952.

Poultry Breeding, written as a textbook for the undergraduate student of poultry husbandry, is meant to appeal to the practical poultry breeder as well. The basic anatomy and physiology of the male and female genitalia, and the basic mechanisms of inheritance, are dealt with in separate introductory chapters. The remaining chapters deal almost exclusively with problems of the practical poultry breeder. The inheritance of color characters, plumage, comb type, and a variety of other morphological characters encountered in poultry breeding are described in detail. The more complex characters, involving many environmental in addition to genetic factors, are discussed in chapters on fertility and hatchability, meat production, egg production, and egg quality. A brief description of the conventional breeding systems is given in a chapter by C. S. Shaffner. This book should continue to enjoy popularity with the audience for which it was intended, the student of poultry husbandry and the practical poultry breeder.

FREDERICK N. ANDREWS

A WORLD DICTIONARY OF BREEDS, TYPES AND VARIETIES OF LIVESTOCK. *Technical Communication No. 8, Commonwealth Bureau of Animal Breeding and Genetics.*

By I. L. Mason. Commonwealth Agricultural Bureaux, Slough, Bucks, England. 30s. 272 pp. 1951.

This work represents the first dictionary of breeds of livestock published in any language. Previously it has been impossible for the average livestock breeder or research worker to identify even the names given livestock in countries other than his own. Some breeds are well known throughout the world under one name, but may be referred to by another in their country of origin. Breeders interested in cross-breeding, the improvement of existing breeds, or the development of new breeds have long needed a reliable reference to the names which have been given the various types, varieties, or breeds of livestock and their outstanding characteristics. The physiologist and the nutritionist encounter the same problem of identification in attempting to evaluate research data from various parts of the world.

The book is divided into two sections. The first contains the names of over 4,000 types of horses, cattle, sheep, swine, goats, asses, and buffaloes. The native name, a recommended English name, and limited information as to the etymology of the name, the origin and distribution of the breed, and its outstanding physical characteristics are given. In the second part, information, whenever available, has been summarized as to the various breeds, and their numbers, which are found in the major countries of the world, except that Asia and Africa are divided into subcontinents instead of countries.

A third portion to complete the dictionary has been proposed. This would contain illustrations of the various breeds and maps showing their distribution. The author has made a great contribution for the livestock breeder, and it is to be hoped that the third section will soon be forthcoming.

FREDERICK N. ANDREWS

THE HORSE. *Judging—Breeding—Feeding—Management—Selling.*

By D. J. Kays. Rinehart & Company, New York and Toronto. $6.00. xvii + 494 pp.; ill. 1953.

It would be an exception for a man who is regarded as one of the great horsemen of his generation to write of the horse without nostalgia. Kays, fortunately, is not that exception. The first 9 chapters of his book are an interesting, well illustrated, authoritative account of the gross anatomy, classification, and judging of draft and light horses. A chapter on the draft breeds, of which Kays is both a noted breeder and judge, "has been included in this text chiefly for its historical importance." Three chapters are devoted to the origin and characteristics of the common breeds of American saddle horses, the Standardbred and the Hackney. The remaining chapters are concerned with breeding, feeding, and horse management problems, and include chapters on parasites and horseshoeing. The basic principles of equitation are dealt with in a separate chapter, and the author closes with a discussion of his philosophy on selling purebred horses. The book contains over 150 illustrations and appropriate poetry and prose to express the author's sentiment for his subject.

"Look back at our struggle for freedom,
Trace our present day's strength to its source;
And you'll find that man's pathway to glory
Is strewn with the bones of a horse."

FREDERICK N. ANDREWS

ANIMAL GROWTH AND DEVELOPMENT

ELEMENTS D'EMBRYOLOGIE. *Deuxième Édition.*

By A. Celestino Da Costa. Masson et Cie., Paris. 2800 fr. (paper). viii + 583 pp.; ill. 1948.

In the present volume, which is a French edition of a Portuguese embryology text for medical students, it is particularly interesting to note what material may be included in a book of moderate size, destined to furnish general biological background as well as instruction in human embryology.

There are three major sections, each followed by a brief bibliography. The first section deals with preliminary phenomena: cytology, gamete formation, and surprisingly, a whole chapter on the fundamentals of Mendelian heredity. If this is the only preparation a medical student is given in genetics, one feels that the pages on human heredity are not very comprehensive. The basic experimental material is very lucidly presented.

The second section deals with general embryology: morphogenesis in the vertebrate classes, a long chapter on mechanisms of development, and a chapter on anomalies. Thus the medical student is exposed to considerable information about classical experimental embryology, transplantation, and isolation, with emphasis on theories of fields and gradients. The section on the physiology of the embryo is unfortunately weak.

The third major section, Special Embryology, deals with differentiation and organogenesis, especially in man. Here, of course, available information exceeds available space (about 200 pages). In some cases one feels that the choice made was not that of most potential value to medical students. For example, the circulatory changes at birth are very inadequately treated.

The figures are numerous, and many of the original diagrams very useful. Unfortunately some of the photographs and drawings are poor, or poorly reproduced. There is an index, and an appendix dealing with the history of embryology.

DOROTHEA RUDNICK

A LABORATORY MANUAL OF COMPARATIVE EMBRYOLOGY.

By Alfred F. Huettner. The MacMillan Company, New York. $1.75 (paper). vi + 114 pp. 1953.

This manual for a semester laboratory in comparative vertebrate embryology is designed for use with the 1949 edition of the author's *Fundamentals of Comparative Embryology of the Vertebrates*. It contains 43 pages of text and 47 of work-sheets, arranged into 25 exercises: mitosis, meiosis, and cleavage in various vertebrates and invertebrates (4 exercises); frog gametogenesis and development (10); chick development (9); and anatomy of the 7¼ mm. pig embryo (2 exercises). Students meet living material through the observation of the effect of temperature on the cleavage rate of the frog egg, the performance of Born's classical pressure experiment, and an examination of the living 72-hour chick embryo. The extent to which the manual deals with

frog and chick embryology would probably meet the needs of the general student, but one might question the advisability of the abrupt and isolated study of the 7¼ mm. pig without any first-hand knowledge of earlier embryogenesis in mammals. The author's directions are succinct and appear clear and workable.

T. O. SIPPEL

ANIMAL MORPHOLOGY

A TEXTBOOK OF ARTHROPOD ANATOMY.

By R. E. Snodgrass. Comstock Publishing Associates, Cornell University Press, Ithaca. $6.00. viii + 363 pp.; ill. 1952.

This book is the outcome of a lifetime of study of insect structure and ancestry. "The arthropods are a group of related invertebrates; arthropodists, for the most part, are a group of unrelated vertebrates. Each specialist, whether an entomologist, a myriapodist, a carcinologist, or an arachnologist, works in his own particular field and gives little thought to the work of specialists in other fields. As a result, the relationships of the various kinds of arthropods to one another are by some ignored, while others propose theories of arthropod phylogeny based on an insufficient knowledge of the anatomy of the arthropods in general." Snodgrass himself has come to the "...disconcerting conclusion that the facts of arthropod structure are not consistent with any proposed theory of arthropod interrelationships." He believes that the arthropods are more closely related to onychophorans than to polychaetes and that the ancestor of the two groups, the polychaetes and the group which gave rise to the onychophorans and arthropods, must have been a primitive annelid far more generalized than present polychaetes. In a way, these remarks are incidental to the main purpose of the book; but they are of great significance as a sobering brake on the activities of over-enthusiastic theorists. Eleven well-defined classes of arthropods are treated here. The two small groups Tardigrada and Pentastomida are not included because of the uncertainty regarding their taxonomic affinities. For each of the classes treated one representative type has been chosen for discussion, although many comparisons within groups and among groups are made. The descriptions are concerned principally with the endo- and exo-skeletons and the musculature, although in some cases the reproductive and respiratory systems are also included. There is a profusion of the excellent type of illustration which has come to be associated with all Snodgrass' work. This is an excellent textbook and guide for courses on arthropod anatomy. It will be extremely useful to students of invertebrate zoology and physiology, as well as to specialists who may have occasion to investigate the anatomy of these animals. It is a masterly piece of work, clearly presented and attractively printed.

V. G. DETHIER

THE ANATOMY OF THE MIGRATORY LOCUST.

By F. O. Albrecht, with a foreword by J. W. Munro. University of London, The Athlone Press. 30s. xvi + 118 pp.; ill. 1953.

In England the migratory locust is replacing the cockroach as a laboratory insect for teaching purposes. Sanitation in America has not yet attained such a degree of efficiency that the cockroach is becoming excessively difficult to obtain. Nevertheless, here too the grasshopper is the insect of choice in elementary courses. With this turn of events, the need for an authoritative reference book on anatomy becomes apparent. Albrecht's monograph is offered as a textbook to fill this need. As such, it is an excellent piece of work. It considers in detail the internal as well as the external anatomy of the locust. The many illustrations are reminiscent of those of Snodgrass in their accuracy and clarity. The author is to be commended for accepting wherever possible the nomenclature of Snodgrass. This procedure makes for uniformity and is especially useful to American students. If this text is not adopted for use in America, it will not be because of any inherent shortcomings, but only because the species treated is not available here. As the author points out, *Locusta* differs in a number of details from the other genera, and it is usually the latter which are available to the student in this country. Nevertheless, it is strongly recommended that this text be examined as a possible standard for use in beginning courses, especially those in entomology. It is unfortunate that the binding is of a quality which will suffer greatly in the hands of even the most considerate student who uses it assiduously.

V. G. DETHIER

BAILEY'S TEXT-BOOK OF HISTOLOGY. *Thirteenth Edition.*

Revised by Philip E. Smith and Wilfred M. Copenhaver, with the assistance of Dorothy D. Johnson. The Williams & Wilkins Company, Baltimore. $9.00. xviii + 775 pp. + 30 pl., text ill. 1953.

The present edition of this well-known textbook is not radically different from the previous one (*Q.R.B.*, 24: 64. 1949). Dorothy Johnson has revised the chapters on glands and the digestive system, and there is some reworking of other sections. Current trends in histochemical and electron microscopic research are reflected to a greater extent than in previous editions. But the approach is conservative, with emphasis on the commoner tissue preparations available in every laboratory

of histology. It should continue to enjoy popularity as one of the histology textbooks well suited to first-year medical students.

F. N. Low

ANIMAL MICROLOGY. *Practical Exercises in Zoological Micro-Technique. Fifth Revised Edition.*

By Michael F. Guyer; with a chapter on drawing by Elizabeth A. (Smith) Bean. The University of Chicago Press, Chicago. $4.75. xviii + 327 pp.; ill. 1953.

MICROTECHNIQUE. *A Student's Guide to Slide-Making. By Arthur W. Jones and John M. Carpenter. Burgess Publishing Company, Minneapolis.* $1.50 (paper). ii + 39 pp. 1952.

Guyer's book, now in its fifth edition, is too well known to animal histologists and cytologists to require an extensive review of either contents or aim. For conventional methods and approaches it is quite adequate and useful. It lacks a modern touch, however. Although the electron microscope is mentioned briefly, the phase microscope is not considered, nor are the more recent histochemical techniques for the intracellular localization of particular systems. The manual by Jones and Carpenter is a loose-leaf form which is intended only as a guide for students, and for use in conjunction with a reference shelf of more highly technical and specific volumes. It can best be considered a laboratory notebook, with space for notes to be taken, and with suggestions for things to be done. The initiative, however, is left up to the student in an effort to encourage independence as well as to provide latitude.

C. P. Swanson

ANIMAL PHYSIOLOGY

TRAITÉ ELÉMENTAIRE DE PHYSIOLOGIE HUMAINE. *Third Edition.*

By Henri Fredericq. Masson et Cie., Paris. Fr. 41.00; $11.72 (paper). 812 pp.; ill. 1952.

Not too much need be said about this textbook. It is fairly adequate, but in many respects too elementary for medical students. Its limitations are partially overcome by the inclusion of a list of reference works—in most cases other textbooks of physiology—but many of these references are not up to date and the general bibliography is extremely poor.

No attempt has been made to point up controversial topics. There is either inadequate discussion, or none at all, of many items, such as certain aspects of electrocardiography, stress, modern theories of neurophysiology, or electrolyte and fluid balance. The field of physiology is covered in a broad sense, in a way that would be adequate for undergraduate students, nurses, and others not at too advanced a level. The illustrations could also stand a great deal of improvement. It is too bad that Professor Fredericq could not have made this revision more nearly what could have been expected from a physiologist of his eminence.

R. G. Grenell

RECENT PROGRESS IN HORMONE RESEARCH. *The Proceedings of the Laurentian Hormone Conference, Vol. VII.*

Edited by Gregory Pincus. Academic Press, New York. $9.50. viii + 527 pp.; ill. 1952.

One-half of the 14 papers presented were concerned with the adrenal gland or its pituitary regulator. Two papers on the chemistry of pituitary corticotrophin (Astwood et al.; Dedman, Farmer, Morris, and Morris) seem effectively to remove this substance from the protein to the polypeptide class. Long suggests two mechanisms for ACTH secretion: a self-regulating humoral system involving the concentration of ACTH and of the adrenal cortical hormones represents a primitive, continuing system, upon which is superimposed a mechanism of rapid release mediated by the sympathetic nervous system. More specialized accounts are those of Haines (biosynthesis in vitro of cortical steroids using adrenal brei and slices); Lloyd (adrenal cortex and fluid metabolism: fluid balance studies in animals and man); Dougherty (cortisone moderates allergic inflammation through a specific antiphlogogenic (sic!) action of its own rather than by an action on the antigen-antibody union); and Baker (histological effects elicited by ACTH and by inanition on endocrine glands, organs, and connective tissue). Also in the field of allergy, it is reported that histamine metabolism is profoundly altered by adrenocortical activity, but neither ACTH or cortisone appears to modify anaphylaxis or skin tests importantly (Rose).

Other discussions were: pituitary-mammary gland relationships—with special reference to the important galactopoietic function, viz., maintenance of lactation (Folley); regulation of the sex cycle through a hypothalamic-pituitary neuro-humoral pathway (Markee, Everett, and Sawyer); gonadal cycles in domestic animals (Gassner); endocrinology of the human menstrual cycle, with a discussion of their menstrual toxin (O. V. and G. V. Smith). Levin and Farber discuss hormonal factors in depot fat mobilization, and indicate that this is mediated by both pituitary and adrenal cortex. The effective pituitary substance seems to be the growth hormone acting directly in the fatty depots. Finally, Mirsky analyses the etiology in that perennial, and ever more complex situation, human diabetes mellitus. As usual, the presentations are enlivened by discussion, and the volume preserves a fine record of what was on the minds of endocrinologists in the summer of 1951.

H. R. Catchpole

RECENT PROGRESS IN HORMONE RESEARCH. *The Proceedings of the Laurentian Hormone Conference, Vol. VIII.*

Edited by Gregory Pincus; Committee on Arrangements, R. W. Bates, R. D. H. Heard, A. D. Odell, G. Pincus, E. C. Reifenstein, Jr., and A. White. Academic Press, New York. $10.80. vi + 603 pp.; ill. 1953.

This volume of *Recent Progress in Hormone Research* covers the following four principal topics: The Chemistry and Biochemistry of Adrenocorticosteroids; Adrenocortical Physiology, a Symposium on Diseases of Adaptation (the feature of the ninth annual meeting of the Laurentian Hormone Conference held in Quebec in September, 1952); The Physiology of Reproduction; The Growth Hormone and Metabolism. It comprises the following papers: Synthesis of 11-Oxygenated Steroids from Plant Sources (Rosenkranz et al.); Hydrolysis and Extraction of Corticoids and 17-Ketosteroids from Body Fluids (Venning et al.); Micromethods for the Analysis of Adrenocortical Steroids (Zaffaroni); The Bioassay of Adrenocortical Hormones (Dorfman); Diseases of Adaptation: Introductory Remarks (Selye); A Consideration of the Relationship of Experimentally Produced and Naturally Occurring Pathologic Changes in the Rat to the Adaptation Diseases (Ingle and Baker); Adrenal Response to Stress in Man (Thorn et al.); Relationship of the Adaptation Concept to the Connective Tissue Diseases (Bauer and Clark); The Adrenal in Cancer (Huggins et al.); Progesterone Metabolism in the Human Female: Its Significance in Relation to Reproduction (Guterman); Biochemistry of Relaxin (Frieden and Hisaw); Problems of Fetal Endocrinology: The Gonadal and Hypophyseal Hormones (Jost); Steroid Action and Interaction in Uterine Metabolism (Szego and Roberts); The Growth Hormone and Diabetes (Young); Anterior Pituitary and Adrenal Hormones in the Regulation of Carbohydrate Metabolism (de Bodo and Sinkoff); The in Vitro Synthesis of Lipids and Its Hormonal Control (Gurin and Brady). The style and format are the same as in the previous editions.

DAVID B. TYLER

THE STORY OF THE ADAPTATION SYNDROME (*Told in the Form of Informal, Illustrated Lectures.*)

By Hans Selye. ACTA, Medical Publishers, Montreal. $4.50 (leather). 225 pp. 1952.

In this informal printing of a group of his lectures, Hans Selye presents a summary of his work and ideas concerning the response of an organism to stress. Briefly outlined, his major theme states that various stimuli exert both specific and non-specific effects on the body. The non-specific stress reaction is the GAS (general adaptation syndrome), the effects of which are mediated through humoral or nervous pathways, or both. The humoral paths lead through the anterior lobe of the pituitary and the adrenal cortex, and their effects largely depend on so-called "conditioning factors" (e.g., diet, temperature, heredity, etc.). The GAS is considered to be "an indispensable physiologic defense reaction to damage as such."

That mechanisms such as these exist, and further, that they are intimately related to what has come to be called psychosomatic illness, is coming to be the prevailing point of view. Selye's previous work has been largely responsible for the elucidation of many of the factors involved. However, many complications exist. The related psychological factors are still obscure, as well as the mechanisms through which they act. Many of the neural and humoral questions are still unanswered, and at the present time too much is being written which is either pure or almost pure conjecture.

It would have been most interesting if Selye had included in his discussion—which is essentially endocrinological—some consideration of the neural and humoral factors involved from the point of view of automatic regulation, i.e., how the endocrines function in these states in relation to control of the system by adequate negative feed-back. Perhaps he will formulate this in later papers. In any case, this is a stimulating, albeit somewhat restricted, discussion of a fascinating and important subject by one of the most outstanding physiologists working in the field. It should be of great interest to physiologists and clinicians.

R. G. GRENELL

BODY TEMPERATURE. *Its Changes with Environment, Disease and Therapy. American Lecture Series No. 147. By W. A. Selle. Charles C Thomas, Springfield.* $3.50. v + 112 pp.; ill. 1952.

This is another little monograph in the American Lecture Series, many of which have proven to be very useful for those who may require a summary, not too detailed, of the literature in a particular field. Selle concerns himself with essentially seven different aspects of this subject: Heat Production, Heat Dissipation, Integrated Temperature Control, Neural Mechanisms of Temperature Regulation, Internal Disturbances of Heat Regulation, Environmental Disturbances of Heat Regulation, and Physical Allergy. References are made to 220 papers, most of which are of fairly recent publication. There is a small, though adequate index for this type of monograph. The price, $3.50, is a little higher than that of previous monographs of this series.

DAVID B. TYLER

BLOOD CLOTTING AND ALLIED PROBLEMS. *Transactions of the Fifth Conference, January 21–22, 1952, New York.*

Edited by Joseph E. Flynn. Josiah Macy, Jr. Foundation, New York. $4.95. 368 pp.; ill. 1952.

This book resembles in its scope and make-up the Transactions of the preceding four Conferences on Blood Clotting which have been reviewed in previous numbers of this journal (see *Q.R.B.*, 27: 415. 1952). It includes 7 major articles reporting work in progress, together with an informal, detailed and critical discussion by other members of the Conference, which is perhaps its most valuable feature.

The subjects considered include comparative studies of the newer anticoagulants and those currently in use by Barker and by Wright. Owren (Oslo, Norway) has contributed a highly informative article on New Clotting Factors, particularly those he terms convertins, accelerin, and their precursors. A brief note has been added in the Appendix, in which the various synonyms of these prothrombin conversion factors are listed.

Three articles deal with the hemostatic disturbances and coagulation defects that follow experimental irradiation of the whole body. An extreme diminution of blood platelets and disturbances directly attributable to this thrombocytopenia appear to be the most important but not the only cause of the bleeding. They make the important observation that although in such animals bleeding is usually conspicuous and important, it does not appear to be the major direct cause of death. Loomis also contributes an article on Fibrinolysin and Antifibrinolysin.

This report is in no sense a textbook nor a résumé of the subject of coagulation. The articles included are authoritative and in substantial degree highly technical. They will be of interest chiefly to those who are actually working in this field or who are well abreast of the pertinent current literature. For such readers they will be useful and are recommended.

PAUL W. CLOUGH

THE SPINAL CORD. *A Ciba Foundation Symposium. Consulting Editors, J. L. Malcolm and J. A. B. Gray. Editor for the Ciba Foundation, G. E. W. Wolstenholme, assisted by Jessie S. Freeman. Little, Brown & Company, Boston.* $6.50. xii + 300 + 3 pl.; text ill. 1953.

Since 1949 the Ciba Foundation has held a series of symposia on varied subjects. The present is the fifth to appear, and deals with experimental studies from a host of viewpoints—anatomical, physiological, pharmacological, etc.—by leading investigators from various parts of the world. The majority of the papers deal with the neurophysiology of reflexes. The supplementing of these contributions by those presenting comparative physiological, developmental, and pharmacological data, as well as by the spontaneous discussions that follow each formal presentation, has succeeded in the production of a small book, which is nonetheless a milestone marking the state of our knowledge of spinal cord potentials, reflexes, and neuronal interrelationships and responses at this time. Consequently, the book will be of inestimable value to biologists and physiologists. Its *immediate* value to clinicians (i.e., neurologists and neurosurgeons) will be less, perhaps, because of the omission of most of the beautiful work of recent years on the spinal cord of man.

R. G. GRENELL

THE HUMAN SENSES.

By Frank A. Geldard. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. x + 365 pp.; ill. 1953.

The Human Senses deals with the bases and concepts of sensory psychophysiology. That this is a fascinating and fundamental field of discussion and investigation is readily appreciated by both scientists and laymen, especially after some consideration of the relationships between sensory stimuli and the total behavior of the living organism. The sensory receptors have come to form a most important part of the new thinking in basic and applied neurophysiology, primarily because of new attitudes concerning their role in the so-called feedback circuits by means of which the organism may adapt to stimuli or alterations in internal and external environment. The sensory or afferent input forms the first part of the environment-organism circuit and is a function of the sensitivity or threshold of the sensory receptor. Behavior is, in part, a reflection of the degree of "contact" existing between the organism and its environment. One is reminded by this of a peculiar phenomenon relative to the interpretation of the electroencephalogram. In order to obtain what has been termed the "normal" electroencephalogram, the subject must be maintained under such conditions that he is cut off as completely as possible from the external environment, i.e., in a completely quiet room, preferably dark, with his eyes closed and as relaxed as he can be. In this way the "normal" EEG waves can be recorded. If, however, the subject's contact with the environment is increased, for example, by opening the eyes, the waves disappear. Superficially it would seem that the EEG pattern is seen only when the subject's level of "consciousness" is minimal. The picture is, of course, much more complex than this would suggest, but such simplification may be useful in thinking about some of these complex psychophysiological interrelationships.

Geldard has not concerned himself with these intricacies of human behavior, but has restricted his discussion to a less controversial, more formal, concise presentation of the psychophysiological data available

relative to the somatic sensory channels—visual, auditory, olfactory, gustatory, and cutaneous. It is unfortunate that the visceral afferent problems have not been considered in as much detail or with as much care, since they are of the utmost importance in the response of the organism to environmental stress and consequently in the etiology of psychosomatic illness.

The material presented is well arranged, written clearly, and with the necessary emphasis on the experimental approach. As would be expected from the author's interests, the concept of human engineering is stressed. Certain improvements can be suggested for future editions. One would like to see more discussion of some of the related general physiological material, e.g., some of the recent findings concerning molecular concepts in olfactory and gustatory activity and chemoreception; some of the concepts and data concerning the role of sensory processes in organismal adaptation; etc. A broader bibliography, in certain respects, would also be helpful. On the whole, however, the book is a good summary of a great deal of complex material, presented in a critical, investigative manner.

R. G. GRENELL

BIOLOGICAL ANTAGONISM. *The Theory of Biological Relativity.*

By Gustav J. Martin. The Blakiston Company, New York, Philadelphia, and Toronto. $8.50. vii + 516 pp.; ill. 1951.

In this volume the author offers the concept of biological relativity as the underlying phenomenon of both pharmacology and toxicology. To illustrate this concept innumerable examples from pharmacology and biochemistry are presented. The *p*-aminobenzoic acid–sulfonamides–folic acid relationship and amino acid analogues are but two of the subjects discussed in some detail. Proteins and protein antagonisms, and analogues of the vitamins, purines, and pyrimidines are also presented, along with brief mention of inorganic metabolite antagonists. The volume is profusely documented with references. While the theory of relativity is not new, the book should find acceptance as an unusually complete review of knowledge in the field up to 1951. It is to be hoped that the author will revise the text periodically to include current findings.

R. VAN REEN

PROCEEDINGS OF THE SOCIETY FOR THE STUDY OF FERTILITY. *Number IV. London Conference, 1952.*

W. Heffer & Sons, Cambridge. 10s. (paper). ii + 63 pp. + 6 pl.; text ill. 1953.

Contains 15 papers: Early Death of the Egg and Embryo in the Aplacental Opossum (Carl G. Hartman); The Cellular Components of the Ovary (S. Zuckerman); The Effect of Intelligence upon Fertility (S. A. Asdell); Mammalian Spermatogenesis (L. A. Harvey); The Morphology of Fowl Sperm (G. W. Grigg); Some Observations on the Morphology of Fowl Spermatozoa (P. E. Lake and J. Smiles); Some Observations on the Morphology of Spermatozoa by Electron Microscopy (C. E. Challice); Electron Microscope Studies on the Morphology of Human Spermatozoa (H. Bayle): Azoospermia of Excretory Origin (H. Bayle); The Morphology of Human Spermatozoa in Relation to Fertility (John Macleod); The Blood Supply of the Rat Epididymis: the Experimental Effects of Certain Arterial Ligations and their Relation to the Problems of Infertility (E. W. Macmillan); An Artificial Spermatocoele (Donald Young); The Effects of "Aspermy" Virus upon Nuclear Behaviour in Certain Solanaceous Plants (John Wilkinson); The Role of Modern Antibiotics in the Treatment of Infertility (Mary Barton); and, Do Operations on the Cervix Influence Sterility? (Bethel Solomons).

ANIMAL NUTRITION

ADVANCES IN FOOD RESEARCH. *Volume IV.*

Edited by E. M. Mrak and G. F. Stewart; Editorial Board, E. C. Bate-Smith, W. H. Cook, W. F. Geddes, M. A. Joslyn, A. J. Kluyver, S. Lepkovsky, B. E. Proctor, Edward Seltzer, P. F. Sharp, W. M. Urbain, and O. B. Williams. Academic Press, New York. $9.00. xiv + 457 pp.; ill. 1953.

The editors of the *Advances in Food Research* have attempted to present, in the several volumes which have appeared so far (see *Q.R.B.*, 27: 111. 1953), a complete coverage of progress in food research. The subjects presented in this volume will be of interest and importance primarily to workers in food industry and food technology. The subjects, and their authors, are as follows: Wiltshire Bacon (N. E. Gibbons); Work Methods Design and Work Simplification (Louis E. Dever); Nutritional Stress Factors and Food Processing (Samuel Lepkovsky); The Chemistry of Chlorophyll (S. Aronoff); Reversion Problems in Edible Fats (B. F. Daubert and Paul W. O'Connell); Fish Preservation in Southeast Asia (A. G. Van Veen); The Effect of Heat upon the Nutritive Value of Protein (Eldon E. Rice and Jack F. Beuk); Insects Attacking Stored Products (A. E. Michelbacher); and The Use of Ascorbic Acid in Processing Foods (J. C. Bauernfeind).

R. VAN REEN

CHEMISTRY OF FOOD AND NUTRITION. *Eighth Edition. By Henry C. Sherman. The MacMillan Company, New York.* $6.00. x + 722 pp.; ill. 1952.

This volume is the latest edition of the well-known textbook originally published in 1911. It is designed primarily for college classes, although the presentation is mostly descriptive and will be understandable to those with an interest in nutrition who are not trained in chemistry. Several revisions of the 7th edition of 1946 have been made in the present volume. A chapter on folic acid, vitamin B_{12}, and the citrovorum factor is presented, as well as new chapters on trends in food consumption and the improvement of already normal nutrition.

R. VAN REEN

B-VITAMINS FOR BLOOD FORMATION. *Publication No. 146, American Lecture Series. A Monograph in American Lectures in Pharmacology.*

By Thomas H. Jukes. Charles C Thomas, Springfield, Ill. $4.00. x + 113 pp.; ill. 1952.

One of the most exciting series of medical investigations of this century began in 1926 with the successful treatment of pernicious anemia with whole liver. Since that time pteroylglutamic acid has been shown to be needed for the cure of certain anemias, vitamin B_{12} has been demonstrated to produce remissions in pernicious anemia, and the citrovorum factor has been shown to have anti-anemia properties. The background of these developments is ably presented by T. H. Jukes in this volume, which will certainly prove valuable to clinicians, students, and researchers alike. The monograph also contains discussions of antagonists of folic acid, metabolic reactions involving folic acid and vitamin B_{12}, and the anemia of vitamin B_6 deficiency.

R. VAN REEN

RECENT ADVANCES IN NUTRITION RESEARCH *With Emphasis on the Newer B Vitamins. Nutrition Symposium Series No. 5. Proceedings of the Scientific Sessions of the Seventh Annual Meeting, The National Vitamin Foundation, New York, April 3, 1952.*

By A. E. Axelrod and 13 others. The National Vitamin Foundation, New York. $1.50 (paper). i + 129 pp.; ill. 1952.

This volume is the fifth in a series of nutrition symposia sponsored by the National Vitamin Foundation, and is devoted to various aspects of work on the B vitamins. The subjects presented are: The Metabolic Role of Crystalline Vitamin B_{12} (B. F. Chow); Observations of Substances Combining with Vitamin B_{12} (B. F. Chow and R. L. Davis); Role of the Vitamins in Antibody Production (A. E. Axelrod); Adrenal Function in Pantothenic Acid Deficiency (W. A. Krehl, R. W. Winters, and R. B. Schultz); Some Studies on the Role of Certain of the B Vitamins in Leukopoiesis (D. R. Weir and R. W. Heinle); The Effect of Certain Nutritional Factors on the Reactions Produced by Acute Stress in Human Subjects (E. P. Ralli); The Skin Lesions of Human Pyridoxine Deficiency and Their Relationship to Seborrheic Dermatitis of the Sicca Type (R. W. Vilter and W. Schreiner); The Role of B Vitamins in the Nutrition of the Pig (R. W. Luecke); and The Comparative Value of Various Antibiotics in Swine Rations (H. D. Wallace and T. J. Cunha). It should be noted that extensive reviews are not presented, but that the papers are devoted more to reports on current research work.

R. VAN REEN

BIOPHYSICS AND GENERAL PHYSIOLOGY

GENERAL PHYSIOLOGY.

By Bradley T. Scheer. John Wiley & Sons, New York; Chapman & Hall, London. $7.00. x + 613 pp.; ill. 1953.

This important new textbook includes significant aspects of recent progress in general physiology, presented in a very satisfactory manner. It was designed, not as an exhaustive treatise, but as material for a thorough first course in physiology for prospective specialists, and it assumes an "adequate working knowledge" of biology, chemistry, and physics. Would that all premedical students could have such a course!

As a personal synthesis, the writing of this volume represents no mean achievement, as it includes a bibliography of over 1400 papers. The facts presented are followed through to reasonable conclusions, rather than being merely listed. The student is introduced to current thought with a minimum of past theory, but with a sure sense of respect for the limitations of current views.

Topics were selected on the basis of whether they permit consideration in mechanistic terms applicable to a wide range of living organisms. The five sections of the book include: 130 pages on the physicochemical foundations of life, including cell structure; 100 pages on biocatalysis and metabolism; 110 pages on energy transformations in cells and organisms; 90 pages on development, including two excellent but necessarily highly tentative chapters on the control of development and the mechanism of differentiation, subjects in need of more attention by physiologists; and a final section on integrations, including a beautifully lucid 50 pages on excitation, conduction, and nervous integration, and a rather meagre 30-page descriptive summary of the elements of humoral integration. All in all, the presentation and the choice of material are so good that it makes one wish to be a beginning student of physiology again so as to get this kind of a running start on the subject and be able to say "Why yes, obviously," to concepts that have been won with so much of that patient look that watches "the last oozings hours by hours."

EVELYN HOWARD

THEORETISCHE BIOLOGIE. *Band II: Stoffwechsel, Wachstum. Second Edition.*

By Ludwig von Bertalanffy. A. Francke AG Verlag, Bern. Sw. fr. 47.50 (cloth); Sw. fr. 43.50 (paper). 418 pp. + 3 pl. + 1 folded chart; text ill. 1951.

This book should appeal to the speculatively minded biologist because it collects in one place a variety of chemical, physical, and mathematical treatments of biological problems. No single problem is treated in great depth, but a wide survey of what has been attempted is made available.

In the first 3 chapters, Der Organismus als physikalisches System, Chemische Grundlagen des Stoffwechsels, and Physikalisch-chemische Grundlagen des Stoffwechsels, the topics covered include those ordinarily found in a book on physical biochemistry: thermodynamics, reaction kinetics, diffusion, biological oxidation, and protein synthesis. In particular, a discussion of "open system" theory is given. A brief chapter subtitled Stoffumtrieb is followed by a chapter on Die Vereinheitlichung der Funktionen, which includes a survey of hormonal action and homeostatic mechanisms. No mathematical treatment of such mechanisms is given. The next chapter, Gesamtstoffwechsel, includes a section in which many quantitative relations between body size and metabolic rate, heart rate, and respiratory rate are assembled and considered theoretically. The long last chapter, Wachstum, includes a great deal of quantitative data on growth, as well as most of the theories proposed to fit the curves. A discussion of Thompson's method of deformation of coordinates and of the Lotka-Volterra type of theory of population growth complete the chapter.

The range of topics is thus great and suffices to make the book extremely interesting. The bibliography is extensive. This book should be of considerable value to the graduate student in general physiology, biophysics, or physical biochemistry and to anyone attracted by the notion "dass es möglich sein müsse, für den Bereich des Lebendigen ebenso ein System exakt fassbarer Gesetzmässigkeiten aufzustellen, wie es für den anorganischen Bereich in Physik und Chemie längst geschehen ist."

PAUL CRANEFIELD

AN OUTLINE OF GENERAL PHYSIOLOGY. *Third Edition. By L. V. Heilbrunn. W. B. Saunders Company, Philadelphia and London.* $10.50. xiii + 818 pp.; ill. 1952.

The progress that has been made in the rapidly growing field of general physiology during the last decade is well reflected in the present edition of Heilbrunn's classical text. When the second edition appeared in 1943, some 6 years after the original edition, it included such notable additions as the vitamin needs of lower organisms, the relation of vitamins to oxidative processes, intracellular enzyme localization, and the use of tracer techniques. In the present edition the extent of revision is shown by the inclusion of almost 1800 new literature citations in the total of approximately 4300 references in the entire book. The general plan of organization has been maintained, although the chapter on tropisms has been omitted. The third edition is longer than the second and has involved complete rewriting of some of the chapters. As would be expected, the chapters on intermediary metabolism, secretion and excretion, and chemical aspects of muscular contraction have been brought up to date, in line with the rapid advances in these fields. The value of this text as a teaching aide as well as a reference source is rated high, especially in view of the extensive author and subject indices.

ALVIN NASON

ADVANCES IN BIOLOGICAL AND MEDICAL PHYSICS. *Volume III.*

Edited by John H. Lawrence and C. A. Tobias. Academic Press, New York. $8.00. x + 368 pp.; ill. 1953.

This current volume contains an interesting article by Mayneord and Sinclair on The Dosimetry of Artificial Radioactive Isotopes. The non-specialist will find that the problems of the distribution of ionization by beta and gamma rays in tissues are clearly discussed, as is also much instrumentation. The problem of diffusion kinetics in the use of isotopes in biological processes is discussed by Solomon, and his views as to how observed distribution curves for various substances can be analysed into components are ably presented. As something of a departure from the title of this book, there is an article by Pressman on Antibodies as Specific Chemical Reagents. This is a most interesting topic, but one that certainly belongs in some other collection of reviews. Much of the experimental work of Pollard and his collaborators is summarized in an article entitled Primary Ionization as a Test of Molecular Organization. It also contains a great deal of physico-chemical data in the field of radiation chemistry. While all may not agree with the interpretations placed on these data, the article is most interesting. Grabar has collected a considerable bibliography on the biological actions of ultrasonic waves, and Kirkpatrick and Pattee describe recent technical advances in x-ray microscopy. Blount does the same for ultraviolet microspectroscopy.

L. J. MULLINS

SYMPOSIUM ON PHYSIOLOGICAL EFFECTS OF RADIATION AT THE CELLULAR LEVEL. *Sponsored by the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, April 12–13, 1951. J. Cell. Comp. Physiol., Vol. 39, Suppl. 2.*

Oak Ridge National Laboratory. Free upon request (paper). 233 pp.; ill. 1952.

This symposium is the Fourth Annual Biology Research Conference, sponsored by the Biology Division of the Oak Ridge National Laboratory in cooperation with the Atomic Energy Commission and the Oak Ridge Institute of Nuclear Studies. The phases covered by the papers include: the effects of radiation on cell respiration and respiratory metabolism (Blinks, Boell); problems related to cell and capillary permeability (McCutcheon, Parpart, and J. W. Green); nerve function and irradiation (Nachmansohn); and two papers which will undoubtedly be of special interest to many investigators —one dealing with analyses of isolated cell components (Dorence) and the other with general, basic problems of organized enzyme systems (D. E. Green). With the exception of the paper by Blinks (which considers the after-effects of atom bombs on marine algae), the presentations dealing directly with radiation effects discuss the consequences of irradiation with x-rays. General discussions follow some of the papers. Although the radiation theme binds these contributions together, the wide range of general physiological problems upon which the presentations and discussions bear makes the symposium of great interest to workers in all phases of fundamental biology.

R. G. GRENELL

BIOCHEMISTRY

TOPICS IN PHYSICAL CHEMISTRY. *A Supplementary Text for Students of Medicine. Second Edition.* *By W. Mansfield Clark. The Williams & Wilkins Company, Baltimore.* $10.00. xviii + 777 pp.; ill. 1952.

The second edition of Mansfield Clark's now famous volume, with its philosophical flavor and leisurely and detailed type of exposition, represents on the whole an expansion in comparison to the original edition (*Q.R.B.*, 24: 159, 1949). No new chapters have been added, but instead there has been a fair amount of rewriting, accompanied by some deletions and additions, and the acquirement of more illustrations of important principles. The general plan is the same as in the first edition; and the relatively unconventional and refreshing text has been maintained. The original edition has been extremely useful for students and workers in experimental biology, especially those in physiology and biochemistry. There is little doubt that the new edition will continue to meet the varied needs of students and workers in grasping the fundamentals of physical chemistry, especially in their relation to biological systems.

ALVIN NASON

FIRST SYMPOSIUM ON CHEMICAL-BIOLOGICAL CORRELATION, MAY 26–27, 1950. *Sponsored by The Chemical-Biological Coordination Center of the National Research Council. National Academy of Sciences-National Research Council, Washington.* $4.00. ii + 415 pp.; ill. 1951.

The purpose of the Symposium on Chemical-Biological Correlation was "to bring together scientists trained in chemistry and biology for discussion of problems concerned with the effect of structure of chemicals on their biological activity and the mechanism of such actions."

The volume consists of 36 papers on such subjects as plant growth regulators, antimalarials, fungicides, and carcinogens, along with papers on groups of compounds such as the arsenosobenzenes and diphenyl compounds. The organization, objectives, and progress of the Chemical Biological Coordination Center (CBCC), the chemical and biological codes employed, and a demonstration of machine biochemorphology correlation of antihistaminic activity and chemical structure by means of the CBCC punch cards is also included.

In the paper on arsenosobenzenes, Doak and Eagle point out that of the three types of arsenicals used in the treatment of spirochetal and protozoal diseases only the arsenoso compounds have a direct parasiticidal activity, the arsonic acids and arseno compounds being active by virtue of their conversion to arsenoso compounds in the animal body. Arsenosobenzene was one of the most toxic and most actively parasiticidal in the entire series tested. Single simple substituents did not significantly affect the activity of the parent arsenosobenzenes. A discussion of the mechanism of action of this group of compounds is presented.

The paper by A. G. Norman and R. L. Weintraub on "Structure-Activity Relationships in Plant Growth Regulators" consists of a compilation of information dealing with chemicals that display an ability to affect such plant growth processes as cell elongation, root initiation, parthenocarpy induction, organ modification, abscission, bud development, root elongation, and seed germination.

Results of screening tests of more than 200 synthetic sympathomimetic amines for activity principally as vasopressor agents, but also for bronchodilator action, uterine motility, intestinal activity, and stimulation of the central nervous system are presented by A. M. Lands.

There was a panel discussion on antimalarials. James G. Horsfall et al. presented a fairly thorough examination of the relationship of variously substituted diphenyl compounds to fungitoxicity, and the probable mechanism of this action.

The Effect of Structural Changes in Plant Insecticides and Related Synthetic Compounds on Their Toxicity to Insects was discussed by H. L. Haller in a paper that covers a large number of compounds and is well documented.

In the paper, The Effect of Drugs on the Physiologically Active Thiol Systems, Maxwell Schubert discusses such drugs as mercurials, arsenicals, antimonials,

various alkyl halides, unsaturated carbonyls, disulfide, sulfur mustards, nitrogen mustards, quinones, naphthoquinones, and alloxan in relation to thiol systems in a variety of organs or organisms.

A very interesting paper on The Influence of Isosteric Replacements Upon Biological Activity, by Harris L. Friedman, discusses the concept of isosterism that was first proposed by Langmuir in 1919. The paper surveys the history of isosterism, classifies the varieties of isosteric replacements which are recorded in the literature, and notes the influence of the replacements on the biological activity of compounds. The author concludes that similarity in biological action need not result from isosteric replacement—isosteres need not be bioisosteres. This is not surprising in view of the complexity of the simplest living systems. By means of isosteric replacements it is possible to discover which chemical groups cannot be eliminated without loss of desired activity, and we can also learn which parts of the molecule are important because of their bulk space characteristics. These facts make possible a more intelligent approach to the synthesis of new compounds. If chemical reactivity polarities are considered, the predictability of bioisosteric replacement is quite high.

A panel discussion on anti-metabolites, carcinogenesis, and cancer therapy completes the volume. All 19 of these papers are extremely brief—some being only one-half page in length—yet a great deal of interesting material is presented.

A valuable feature of this volume is the inclusion of the discussions following each paper. Frequently they bring out additional items of great interest.

The volume as a whole should be of great value to anyone working on correlations between chemical structure and biological activity, regardless of whether his principal interest lies in cancer chemotherapy, fungicides, insecticides, plant growth regulators, or some other related field. The approaches to the special problems in most cases are quite similar, and investigators in one field can profit materially by examining the methods and techniques employed and the results obtained in a similar related field in which this fascinating correlation is involved.

C. E. MINARIK

HISTOCHEMISTRY, *Theoretical and Applied.*

By A. G. Everson Pearse. Little, Brown & Company, Boston. $12.00. viii + 530 pp. + 30 pl.; text ill. 1953.

This is a very comprehensive treatise on the theoretical and practical aspects of microscopical histochemical techniques. The author has tested most of the techniques he has described and he provides full details, together with critical comments, as to the usefulness and limitations of each particular method. The appendix of the book, consisting of 85 pages, is a separate, complete unit in itself in which many of the methods are separately detailed. The following subjects are dealt with: The Chemistry of Fixation; Preparation of Tissues by Freeze-drying; Proteins and Amino-acids; The Histochemistry of some Important Simple Proteins; Conjugated Proteins (Nucleoproteins); Carbohydrates; Lipids and Lipoproteins; Aldehydes and Ketones; Alkaline Phosphatases; Acid Phosphatases; Esterases; Glycosidases, Oxidases, and Dehydrogenases; Enzymes as Histochemical Reagents; Pigments; Inorganic Constituents; and Physical Methods. The subject and author index is very adequate, and each chapter is concluded with a very substantial bibliography. This book should be available in every university library that claims a Department of Biology. It can be considered a very valuable addition to the personal libraries of workers both in histology and biochemistry.

DAVID B. TYLER

EIWEISS.

By Heinrich Hellmann. Curt E. Schwab, Stuttgart. DM. 5.80. 159 pp.; ill. 1952.

This is a very lucid report on the present state of protein chemistry. Although written for the layman, it is fascinating and valuable reading for the biologist. The author, in his tendency to simplify, never goes too far, and avoids trivialities. The first part of the book deals with amino acids, protein structure, molecular weights, and the shape of the molecules. In a second special part, various proteins, including enzymes and hormones, are described. The book is highly recommended as an introduction to protein chemistry.

FELIX HAUROWITZ

BIOCHEMISTRY AND PHYSIOLOGY OF NUTRITION. *Volumes I and II.*

Edited by Geoffrey H. Bourne and George W. Kidder. Academic Press, New York. $15.00 per vol. (I) xii + 639 pp.; ill. (II) xii + 640 pp.; ill. 1953.

This treatise in two volumes represents the most ambitious undertaking to appear so far, among the numerous texts related to the science of nutrition. The editors and contributors are to be congratulated in taking the approach that a consideration only of the materials consumed by an organism is no longer adequate to cover the modern aspects of nutrition. With this in view, discussions are presented not only of the major nutrients, such as carbohydrate, fats, proteins, vitamins, minerals, and water, but also of respiratory, hydrolytic, and phosphorolytic enzymes, coenzymes, the relationships of nutritional state to cellular and tissue structure, and the roles of microorganisms in nutrition. While certain of the topics have been reviewed recently in various periodicals and monographs, the present volumes have the

distinct advantage of presenting a unified picture of the current state of nutritional research.

Volume I. The Early Development of the Science of Nutrition (E. P. Cathcart); The History of Vitamins (L. J. Harris); Water and Electrolyte Metabolism (R. L. Zwemer); Carbohydrate Metabolism (T. L. Sourkes); Amino Acids (A. Meister); Biosynthesis of Proteins (H. Boorsook and C. L. Deasy); Lipid Metabolism (A. C. Frazer); Fat Soluble Vitamins (T. Moore); Vitamin B Complex (S. K. Kon and J. W. G. Porter); Vitamins and Hematopoiesis (T. H. Jukes) and Vitamin C (B. B. Lloyd and H. M. Sinclair).

Volume II. The Intracellular Localization by Histochemical Methods of Enzymes and Vitamins (G. H. Bourne); Structural Changes in Vitamin Deficiency (G. H. Bourne); Microbiology of Digestion (D. P. Cuthbertson and A. T. Phillipson); Nutrition of Invertebrate Animals (G. W. Kidder); Energetics and Metabolic Function (E. P. Kennedy); Hydrolytic and Phosphorolytic Enzymes (W. H. Yudkin); Respiratory Enzymes (B. L. Horecker and A. Kornberg); Coenzymes (G. D. Novelli and M. Soodak); Iron Metabolism (H. F. W. Kirkpatrick); Calcium and Phosphorus Metabolism (H. F. W. Kirkpatrick and J. D. Robertson); Trace Elements (E. J. Underwood); and Application to Human Nutrition (G. A. Goldsmith).

R. Van Reen

The Biochemistry of Gastric Acid Secretion. *By Edward J. Conway. Charles C Thomas, Springfield, Ill.* $6.50. xi + 185 pp.; ill. 1953.

The production of high concentrations of hydrogen ions in the gastric secretions has been a challenging problem for a number of years. In this short monograph, Conway offers with considerable enthusiasm much which will be of interest not only to biochemists and physiologists but also to clinicians. There is presented first a brief review of the histochemical studies which have contributed to knowledge of the site of acid formation; basic physiological relationships are then noted. The general problem of the secretion of hydrogen ions is discussed, with a brief summary of recent work on yeast cells. The several theories and the experimental studies on the source of the hydrogen ions are reviewed: the organic acid theory, the "redox" theory, and the contributions of Hollander, Davenport, Davies, Teorell, and others. There follow discussions of free energy relationships, of the significance of gastric potentials, and of neutralization. In the concluding chapter on the role of gastric urease, Conway fully endorses FitzGerald's theory of neutralization of acid by ammonia formed from urea. Some of the results ascribed to the administration of large doses of urea to patients with peptic ulcers are summarized.

This monograph is, without question, stimulating. It is unfortunately marred by numerous typographical errors, by inaccuracies in the references, and by the application of questionable simplifications of fundamental thermodynamic relationships. The contents of the last chapter may eventually lead to the cure of some peptic ulcers. It is possible, however, that the contents of this and the preceding chapters may lead to the aggravation of others.

Francis P. Chinard

Chemistry and Methods of Enzymes. *Third Edition, Revised and Enlarged.*

By James B. Sumner and G. Fred Somers. Academic Press, New York. $7.50. xvi + 462 pp.; ill. 1953.

This highly successful enzyme volume now appearing in its third edition has had to deal with a vast amount of new material since 1947, the date of appearance of the second edition (*Q.R.B.*, 22: 358. 1947). The compactness of the present edition, despite the tremendous developments in nearly every phase of enzyme chemistry, is a credit to the authors and publishers. All chapters have necessarily been revised so as to result in the removal or condensation of some of the older material, while the sections on kinetics and mechanism have been expanded. This edition will doubtless continue to serve as a handbook and general survey of enzyme chemistry for the student and research worker. Whether it will enjoy the wide circulation of the previous editions is questionable, in view of the recent publications of *The Enzymes*, edited by Sumner and Myrbäck, and the forthcoming *Methods in Enzymology*, edited by Colowick and Kaplan, which is to appear under the imprint of the same publisher.

Alvin Nason

Biological Transformations of Starch and Cellulose. *Biochemical Society Symposia No. 11. A Symposium held at The London School of Hygiene and Tropical Medicine on 21 February, 1953.*

Organized and edited by R. T. Williams. Cambridge University Press, New York, $2.25 (paper). iv + 84 pp.; ill. 1953.

This symposium includes articles on the Biological Synthesis of Starch (E. J. Bourne), Enzymic Breakdown of Starch (W. J. Whelan), Starch Synthesis and Degradation in Vitro (Helen Porter), The Chemistry and Degradation of Cellulose (G. O. Aspinall), Cellulases (M. V. Tracey), Digestion of Cellulose by Ruminants (A. T. Phillipson), and The Occurrence and Prevention of the Biological Attack of Cellulosic Textile Fibers (R. G. Fargher). The work on the synthesis and degradation of starch by isolated enzymes is by far the most advanced, and the articles by Bourne and Whelan consequently have the most to offer in terms of specific biochemical knowledge. The correlation of isolated

enzyme activities with reactions in vivo is always a much more difficult subject; and the paper by Helen Porter points out many of the observations on starch metabolism which will eventually be explained only in terms of the interactions of several enzymes or of the products of their reactions.

Research on the metabolism of cellulose is in a much more backward state, and the papers presented here will serve to point up the vast gaps in knowledge of this subject. In particular, there is as yet no idea as to the mode of synthesis of cellulose. This can be contrasted with the discussion by Bourne of at least 5 enzymes capable of synthesizing starches.

A. T. JAGENDORF

LIPID METABOLISM. *Biochemical Society Symposia No. 9. A Symposium held at the London School of Hygiene and Tropical Medicine on 16 February, 1952.*

Organised and edited by R. T. Williams. Cambridge University Press, New York. $2.75. vi + 102 pp.; ill. 1952.

Lipid metabolism has received considerable attention from researchers during recent years, and therefore an integration of the various approaches to the subject in one volume performs a needed service. The subjects presented are as follows: The Mechanism of Fat Absorption (A. C. Frazer); Comparative Aspects of Lipid Absorption and Excretion (R. P. Cook); Defective Fat Absorption in Man (J. M. French); Fat Synthesis from Small Molecules (G. Popják); Aspects of Fat Metabolism in the Ruminant (S. J. Folley); Enzymic Oxidation of Fatty Acids (A. L. Lehninger); and Essential Fatty Acids and Their Relation to Pyridoxine (H. M. Sinclair). Inevitably, current reports in the literature have already contributed more recent information, particularly concerning the enzymic oxidation of fatty acids, and it is to be hoped that further reviews will bridge this gap.

R. VAN REEN

STUDIES ON THE NATURAL FATS. *Volume I, Parts I–III.*

By A. R. S. Kartha. Published by the Author, Maharaja's College, Ernakulam, Travancore-Cochin State, India. 60 cents (paper). 143 pp. + 1 folding table. 1951.

STUDIES ON THE NATURAL FATS. *Volume II, Part IV. Some Applications of Results Reported in Studies on the Natural Fats.*

By A. R. S. Kartha. Published by the Author; printed at the Keralamitram Press, Ernakulam. 40 cents (paper). ii + 111 pp. 1951.

These volumes are concerned with the author's research on various phases of the chemistry of fats. Volume I contains technics for the oxidation of natural fats and separation of the oxidation products, the determination of the type of distribution of glycerides in some natural fats, and the presentation of a hypothesis of the fluidizing function of the unsaturated acids in the natural fats. Volume II is devoted to a general discussion of the component acids of natural fats in relation to the fluidizing theory. Also, considerable attention is given to the changes made in fats which are injected into animals.

R. VAN REEN

CHEMICAL PHYSIOLOGY OF CONTRACTION IN BODY AND HEART MUSCLE.

By A. Szent-Györgyi. Academic Press, New York. $4.80. xviii + 135 pp. + 3 pl.; text ill. 1953.

Szent-Györgyi writes as well as he speaks. Most of those who have heard him at the many conferences or seminars in which he has participated, irrespective of whether they agree or disagree with his views, are fascinated by the enthusiastic manner in which his material and ideas—particularly the ideas—are presented. Here is a synthetic, not a synoptic, monograph in which the author ties many facts and theories together and makes them sound reasonably acceptable. The monograph is divided into three parts, the first dealing with Molecular Mechanism of Motion, the second with the Study of the Heart Muscle Fibre, and the third with Interpretations. The following quotations may be of interest in that they reveal something of the nature of the author's style and philosophy: "The leitmotif of the author's research has always been the conviction that there is but one life and one living matter in this world. This living matter has overgrown the earth, has taken up different shapes, colors, and complexities adapting itself to the most different circumstances. This life is based on a very limited number of basic principles—and the author's endeavor is to understand them" (p. 1). On p. 99, we read "... there is one point I want to touch upon, even at the *risk of speculation*" (italics added). Szent-Györgyi hesitant "at the risk of speculation" is, I believe, a news item of interest to many biologists.

DAVID B. TYLER

EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE. *Treizième Série.*

By MM. P. Boulanger, M.-J. Dallemagne, C.-E. Dent, P. Favarger, A. Gajdos and M. Gajdos-Török, R. Grangaud, E. Mach and R.-S. Mach, M. Machebœuf, P. Mandel, J. Roche, M. Polonovski and P. Valdiguié, G. Schapira and J. Kruh, J. Van de Velde and J. de Smet. Edited by Michel Polonovski. Masson & Cie, Paris. 1650 fr. (paper). iv + 331 pp.; text ill. 1951.

This volume continues the major trend set by its prede-

cessors of effectively relating fundamental biochemistry to clinical problems. Such relationships are described, for example, in reviews on the metabolic effects of cortisone and ACTH (R.-S. Mach and E. Mach), sex hormones and bone (Dallemagne), the intestinal absorption of fatty acids (Favarger), and hemoglobins and "molecular" diseases (Schapira and Kruh). Other reviews with greater biochemical emphasis are those on pentose and desoxypentose nucleic acids (Mandel), the biosynthesis of protoporphyrin IX (Gajdos and Gajdos-Török), carotenoids and vision (Grangaud), amino acid metabolism (Dent), glutamic acid and brain metabolism (Boulanger), hormones and lipid metabolism (Van de Velde and de Smet), the biochemistry of the thyroid hormone (Roche), the metabolism of acetone (Polonovski and Valdiguié), and the copper-containing proteins of blood (Macheboeuf).

FRANCIS P. CHINARD

ION EXCHANGERS IN ANALYTICAL CHEMISTRY.

By Olof Samuelson. John Wiley & Sons, New York; Almqvist & Wiksell, Stockholm. $6.50. xviii + 291 pp.; ill. 1953.

The widespread use of ion exchange resins in medicine and biological research makes it mandatory for a worker in these fields to have a fundamental knowledge of the ion exchange technique. This book presents an understandable and comprehensive discussion of the use of ion exchange resins in not only purely chemical problems but in relation to biochemical and biological applications as well. The volume is divided into three parts. A general discussion of the fundamental properties of ion exchange resins, ion exchange equilibria, and kinetics, along with a consideration of ion exchange in column operation, makes up Part I. Part II is devoted to practical applications of the ion exchange technique and includes discussions of the choice of a resin, purification, the sorption step, the washing step, and elution. Part III covers various applications of the method in the determination of total salt concentration, isolation of trace constituents, isolation of low molecular weight organic acids, and many other specific procedures. The scope and clarity of presentation is certain to make this book a valuable asset to workers in both biology and biochemistry.

R. VAN REEN

MICROBIOLOGY

PRINCIPLES OF MICROBIOLOGY.

By Walter W. Krueger. W. B. Saunders Company, Philadelphia and London. $5.50. xxiii + 648 pp.; ill. 1953.

This textbook for an introductory course in microbiology for college students is divided into nine parts. The first three deal with the history, chemical composition, physiology, and classification of microorganisms. Included are Bacteria, Fungi, Protozoa, Rickettsiae, and Viruses. Part IV is on Techniques and Methods and includes the action of physical, chemical, and chemotherapeutic agents on microorganisms. Part V is on Soil and Industrial Bacteriology, Part VI on Sewage and Water, and Part VII on Foods. Part VIII is on Infection and Body Defenses, and Part IX on Infectious Diseases, with a final chapter on Plant Diseases.

The treatment of the subject matter is clear and concise and on the whole quite accurate. The scope of the book is so broad that brevity is a necessity. References are given at the end of each chapter, and also a series of questions. The illustrations are good.

This book is designed for a general lecture course which must cover a great deal of material in a short period of time. For this purpose it appears very satisfactory.

ELIZABETH I. PETRAN

VIRUSES. *Cold Spring Harbor Symposia on Quantitative Biology, Volume XVIII.*

The Biology Laboratory, Cold Spring Harbor. $8.00. xvi + 301 pp.; ill. 1953.

To those who regard viruses as merely causes of disease and, therefore, of little general interest, Volume XVIII of the Cold Spring Harbor Symposia on Quantitative Biology should certainly bring them into touch with reality. Seldom have so many concepts and experimental results that are basic to all biology been recorded in one volume. Here in three hundred pages the reader will find 42 papers, most of which consider viruses for their general biological interest rather than for the pathology they produce.

This symposium was organized around the three stages of virus development according to concepts which emerged from the bacteriophage meetings at Royaumont, France, two years ago. These stages are the infective, vegetative, and provirus. The infective stage, as its name implies, is the stage which until a few years ago was the only one generally recognized. It is the only stage capable of surviving outside the host. In the case of T_2 bacteriophage, which has been studied most thoroughly, infection consists of the attachment and injection of virus material, mainly desoxyribose nucleic acid, into the host cell. At this point the vegetative stage is initiated. This stage involves the adjustment by the cellular metabolic systems so that the characteristic determinants of upwards of a hundred or more virus particles are formed in each cell. Maturation or conversion of the vegetative stage to infective particles follows the vegetative development. The provirus stage develops in certain strains of bacteria in place of the vegetative stage. These bacteria are able to modify the material that the infective virus injects so that it

does not go into the vegetative stage. In this modified or mollified form, called the provirus, it behaves as though it were a part of the host chromosome, dividing at the same rate that the cell divides so that all daughter cells carry the characteristic. This provirus remains latent until some external stimulant, such as ultraviolet light, peroxide, mustard, or certain nutrillites, induces its conversion back into the vegetative phase, which then develops into mature infective virus. This latent or provirus state has been known as lysogenesis in bacteria for two decades, but its importance has not been generally recognized. The recent discovery by Lwoff and his associates of a variety of methods of stimulating the conversion of provirus to infective particles in a fair proportion of the cells has resulted in an increased interest in the subject.

In addition to the emphasis on the three stages of virus replication and the transition of one stage to another, many other fascinating related biological phenomena are discussed. These include: genetic recombination in viruses and bacteria; host-induced modifications of viruses; and infective heredity in bacteria. The physical, chemical, morphological, and immunological structures of certain viruses are also reviewed. Finally, the newer techniques in the tissue culture of animal viruses are described—especially the plaque formation on plates, which permits more precise estimates of the virus concentration and also the isolation of pure strains from single plaques.

The structure of nucleic acids, particularly those of the desoxyribose type, is also considered in the light of the latest evidence and theory.

This volume is recommended without reservation. It is a review and sourcebook of much that is new in this fascinating field.

ROGER M. HERRIOTT

ADVANCES IN VIRUS RESEARCH. *Volume I.* *Edited by Kenneth M. Smith and Max A. Lauffer.* *Academic Press, New York.* $8.00. viii + 362 pp.; ill. 1953.

This is the first in a projected series of volumes, to appear annually, on the subject of viruses. It is proposed to present review articles on all phases of virus research that place emphasis on the properties and activities of the viral organism itself, rather than on the diseases produced. The appearance of such a series fulfills a very distinct need, since the literature on virus research is scattered throughout journals of biochemistry and biophysics, and of animal, plant, and microbial physiology and pathology. By gathering together much of this material in an annual publication, *Advances in Virus Research* can be of major importance in the evolution of a subject which one might be tempted to call Comparative Virology.

The diversity of organisms that go under the name "virus" is well illustrated by the articles in this first volume. Most attention in recent years has centered on the bacteriophage system, which is one of the easiest to manipulate. H. T. Epstein reviews the properties of bacteriophages, as determined during the past fifteen years, in the first article of the book. His review constitutes a definitive introduction to the bacteriophage system. The variety of experimental approach needed to investigate a virus system is aptly shown here: the experiments considered utilize the techniques of biology, biochemistry, genetics, and biophysics. Although in a not especially critical fashion, Epstein presents a comprehensive picture of the details of the bacteriophage life cycle that are now known. A remarkable start has been made toward the final goal of elucidating the chemical mechanism of virus reproduction. Only a brief mention is made in this article of the lysogenic bacteriophage. It can be hoped that a review in the near future will discuss the genetic implications developing from the study of these inactive viruses.

The multiplication of influenza virus is reviewed in great detail, and in a critical fashion, by Werner Henle. This virus seems to be similar to the bacteriophages in many details of its life cycle. These include the phenomena of genetic exchange among strains, adsorption onto host cells, intracellular growth of non-infective virus, and final liberation of the completed virus.

Insect Viruses are reviewed by G. H. Bergold. These are viruses containing desoxyribosenucleic acid, like the bacteriophages and influenza virus; however, much less is known about their mechanism of duplication. Most interest is focused here on the production of large amounts of anomalous protein in the infected host cell —the polyhedral bodies, in particular. This protein is not infective, and its relation to virus, on the one hand, and to the host cell, on the other, is not at all clear. A further problem of great interest in these viruses is the question of the mechanism responsible for triggering latent virus into active virus. At present many environmental conditions seem to be capable of activating latent insect viruses, which otherwise are carried along without symptoms for many generations. The nature of this inactive virus is also a question not yet resolved.

Joseph Melnick reviews the work on Poliomyelitis Virus, and a brief survey of the isolation and properties of about ten other animal viruses is presented by D. Gordon Sharp.

Plant viruses are represented in two articles. L. M. Black presents the findings that have led to the conclusion that some viruses are capable of multiplication in alternate hosts, from the plant and animal kingdoms respectively. A number of the plant viruses that are transmitted by cicadellids are able to multiply in the insect as well as in the plant. The historical development of this relationship is a provocative question. In addition, the elucidation of the requirements for multiplication of these viruses should contribute to concepts of comparative physiology and biochemistry of very

diverse organisms. Interactions of plant viruses and virus strains on the plant hosts are discussed by C. W. Bennett. Most of the interactions are antagonistic; yet apparently most of these are not explainable on the basis of the production of antibodies by the host, as would be possible for animal viruses.

The book concludes with an article by Roy Markham on the chemistry of virus nucleic acids. The possibility is raised, in his discussion, that the nucleic acids of the viruses—ribonucleic acid for most plant viruses, and desoxyribosenucleic acid for the animal viruses—are responsible for the transmission of genetic characteristics of the virus during reduplication. If so, the chemistry of virus nucleic acids becomes the chemistry of relatively simple genetic material, and this field may have much to contribute, in the future, to a solution of the problems of heredity.

There are some minor typographical errors in the book, but the editorial standards are for the most part very high. The appearance of this series of reviews is a welcome addition to the number of those books collecting and summarizing recent advances in modern biology.

A. T. JAGENDORF

ADAPTATION IN MICRO-ORGANISMS. *Third Symposium of the Society for General Microbiology, Held at The Royal Institution, London, April 1953.*

Published for the Society for General Microbiology. Cambridge University Press, New York. $6.00. x +339 pp. + 6 pl.; text ill. 1953.

The quality of the papers presented at this symposium is as heterogeneous as a bacterial population. Those which deal specifically with the induced synthesis of enzymes (Slonimski, Spiegelman and Halvorson, Cohn and Monod, Pollock) are excellent with regard to the relevance of the contributions they make and in the clarity of thought expressed; the others range from this high level downward. In one of the recorded discussions Pirie said: "This Symposium has produced a rich crop of metaphysics." As far as a reader can tell, he was right; there is often exhibited a considerable ignorance of fact as well as of theory and a tendency to dissociate interpretation from the careful experimental testing of hypothesis that constitutes good science. The result is at times a monstrous confusion.

Even Stanier, whose paper is in general of better quality, uses the term "physiological adaptation" in two contradictory ways. The same author makes an illuminating quotation from Lichtenberg: "Es ist ein grosser Unterschied zwischen 'etwas noch glauben' und es 'wieder glauben.' 'Noch glauben,' dass der Mond auf die Pflanzen würke, verrät Dummheit und Aberglaube, aber es 'wieder glauben' zeigt von Philosophie und Nachdenken." It is illuminating because a goodly number of bacteriologists seem "still to believe" in mechanisms of the origin of bacterial variation that postulate acquired heredity. It would be easier to rationalize the expenditure of time required to appreciate their theoretical positions if it seemed that they "believed again" in these mechanisms after having studied and understood the evidence and alternative interpretations at present available.

Dean and Hinshelwood, for example, in attempting to force their physico-chemical model on bacterial systems, clearly do not appreciate that in most quarters it was long ago understood that adaptation could involve the appearance and selection of preadapted genotypes, the physiological adjustment of genotypically competent organisms, or both. The latter class of events has been illuminated by Monod, Pollock, and others with evidence of a relevance that Hinshelwood's work has never approached. Dean and Hinshelwood do not even refer to this classical work. They avoid coming to grips with the alternatives that others have proposed for their findings by misrepresentations such as the following: "The discussion of these subtler matters [the origin of variation] has until recently usually been met with the comment that the discussion of the changes in the cell reaction pattern was in any case Lamarckian, contrary to modern biological thought, and the like." Luria's single accusation in 1947 that bacteriology was one of the last strongholds of Lamarckianism must have struck deeply. Dean and Hinshelwood's paper contains many errors of fact that the reader must guard against (e.g., the statement that mutants "appear not to increase in number in the absence of the selective agent"), yet they find it possible to be patronizing and to write: "chemists of today . . . would have small patience with . . . doctrinal arguments of a distinctly scholastic flavour." It is a pleasure for the reader to pass to the article of Abraham, who, although he occupies the same position as Dean and Hinshelwood regarding the origin of drug resistance, is much more circumspect. His reasoning is not incisive, but he makes an attempt at objectivity.

The volume contains several other papers which can be said to deal with aspects of adaptation. Those papers on the induced synthesis of enzymes, which in themselves make the publication worth while, adequately treat that major means of microbial adaptation. But there is to be found no paper which specifically deals with microbial mutation or selection, an omission which need not have been made when so much is now known of these mechanisms that form the other major and often complementary means of adaptation among microorganisms. Thus the reader interested in the present status of this most important biological principle, adaptation, may leave this volume with a wrong impression. It is good, however, to see several pleas that microbiologists should behave as other biologists and use the term "adaptation" to refer to all satisfactory adjustments made by organisms to their environments *irrespective of the mechanism adopted.*

Parenthetically, those concerned with the conse-

quences of the McCarran Act may be interested to know that Slonimski, a Polish citizen residing in Paris, was not permitted to enter England. His paper was read for him.

FRANCIS J. RYAN

HEALTH AND DISEASE

THE INFECTIOUS DISEASES OF DOMESTIC ANIMALS *with Special Reference to Etiology, Diagnosis, and Biology Therapy. Second Edition.*

By William Arthur Hagan and Dorsey William Bruner. Comstock Publishing Company, Ithaca. $8.00. xxx + 920 pp.; ill. 1951.

This textbook was written for students of veterinary medicine who have already acquired a background in the general principles of bacteriology and microbiology. It deals, as the title suggests, with infectious diseases of domestic animals, whether due to bacteria, fungi, protozoa, viruses, or microorganisms of uncertain classification. Some of the diseases which are of economic importance in animals constitute human health problems as well. Some of these, e.g., brucellosis and rabies, are dealt with at length. In general the morphological and cultural characteristics of each organism are described briefly. Major emphasis is placed upon the etiology, diagnosis, immunity, and control of each specific disease. Most of the diseases discussed occur in North America, but brief descriptions are given for other livestock diseases that occur in important livestock-producing areas of the world. A separate chapter is devoted to chemotherapy and antibiotics, and the effects of such treatments are mentioned, when known, in the discussions of the various microorganisms.

FREDERICK N. ANDREWS

ANNUAL REVIEW OF MEDICINE. *Volume 4.*

Editor, Windsor C. Cutting; Associate Editor, Henry W. Newman. Annual Reviews, Stanford. $6.00. x + 452 pp. 1953.

The editors are now attempting to select authors on a more international basis than was the case for previous editions, and also to encourage a more detailed consideration of a smaller portion of the literature in a given field rather than "skimming over the whole." Such a policy is particularly suitable to this *Annual Review*, since it contains a very excellent annotated list of reviews prepared by Eaton M. MacKay, a list which should aid those seeking a more complete coverage in any specific field. In this edition the authors have made a serious attempt to be more critical and thoughtful in their presentation, particularly in the fields within which they are most at home. The ratio of the number of references cited by the authors to the number of pages allotted to the review may, to a limited extent, indicate whether the treatise in question is a "skimming over" or a thoughtful, critical review. The number following the reviews covered in this volume is such a ratio and indicates the average number of references per printed page: Infectious Diseases (2); Diseases of the Gastrointestinal Tract (4); Diseases of the Cardiovascular System (8); Diseases of the Kidneys (9); Diseases of the Reticuloendothelial System and Hematology (11); Nutrition (5); Allergy (21); Neoplastic Diseases: Some Metabolic Aspects (4); Diseases of the Female Reproductive System (10); Vascular Diseases of the Brain (5); Psychiatry (6); Diseases of the Respiratory System (6); Physical Agents and Trauma: Burns and Freezing (7); Radiology (4); Diseases of the Bones and Joints (6); Obstetrics (4); Tropical Diseases (13); and Plastic Surgery: Wound Care and Skin Grafting (3).

DAVID B. TYLER

CLINICAL ENDOCRINOLOGY.

By Karl E. Paschkis, Abraham E. Rakoff, and Abraham Cantarow. Paul B. Hoeber, New York. $16.00. xli + 830 pp. + 3 pl.; text ill. 1953.

Within a relatively short period knowledge of the physiology, biochemistry, and pathology of the endocrine glands has expanded tremendously. With the application of this knowledge the diagnostic procedures, therapeutic indications and contraindications, and the very concepts of clinical endocrinology have undergone a complete metamorphosis. To bring together the essential new basic knowledge and the clinical application is no small task. The authors, Paschkis, Rakoff, and Cantarow, are admirably fitted for this, having worked for years in the field of gynecology. Their writing is the product of a unified team which has pulled together. It is remarkable that so much information can be condensed into a single volume. The authors have a proper balance in the selection of the essential information concerning the function of the endocrine glands and in the application of this to the study and treatment of the clinical disorders. The orthodox method of considering each gland in a separate section is followed. This has the advantage of permitting a consideration of the embryology, anatomy, histology, physiology, pathology, and pathologic physiology of each gland together with the diagnosis and treatment of its disorders. The only disadvantage to this method of presentation from the clinician's standpoint is that patients with syndromes such as sexual precocity or infantilism do not present themselves already labelled in regard to the endocrine category into which they fit.

This is a text which can be recommended most highly to the student, the clinician, and the research worker in endocrinology. In condensing such a wealth of material into a single volume it has been necessary to present many subjects very briefly, and additional reading of

various sources will be required. This is facilitated by the excellent annotations and references. Both the information presented and its interpretation are sound and reliable, although it would be possible of course to pick some points on which there are differences of opinion. The form of the book is pleasing and the illustrations are excellent. In short, the reviewer is delighted to have his copy!

LAWSON WILKINS

MECHANISM OF CORTICOSTEROID ACTION IN DISEASE PROCESSES. *Ann. N. Y. Acad. Sci., Vol. 56, Art. 4. Editor, Roy Waldo Miner; Consulting Editor, Oscar Hechter. New York Academy of Sciences, New York.* $3.50 (paper). Pp. 623–814; ill. 1953.

This book results from a series of papers given at a Conference held by the Section of Biology of The New York Academy of Sciences in October, 1952. It consists of 22 papers and should be of interest primarily to endocrinologists.

DAVID B. TYLER

THE EFFECT OF ACTH AND CORTISONE UPON INFECTION AND RESISTANCE. *Symposium held at the New York Academy of Medicine, March 27–28, 1952. Edited by Gregory Shwartzman. Columbia University Press, New York.* $5.50. x + 204 pp.; ill. 1953.

The varied physiological activities of the adrenocortical and adrenocorticotrophic hormones, as well as their role in infectious disease processes, constitute the main subject matter of this volume. Evidence is brought forth that the concepts of infection and resistance include factors in addition to the antigens elaborated by the invading microorganisms and the specific immune response of the host. Although awareness of the impact of these non-specific host reactions on the disease process existed prior to the discovery of cortisone and ACTH, the availability of these hormones in purified form has markedly stimulated research in this area. That these studies have been extremely fruitful is indicated by a mere perusal of the table of contents. These hormones have been shown to alter the course of experimental infections in animal or human disease through facilitating the invasion of tissues by pathogens. To cite but a few examples of the many which have received careful study, one may mention experimental tuberculosis and syphilis in the rabbit and pneumococcal pneumonia and malaria in human beings. Cortisone has been demonstrated to activate latent trypanosomiasis in monkeys and to alter the course of experimental poliomyelitis in hamsters from that of a mild disease with a relative low mortality rate to an explosive, uniformly fatal process.

Related to these observations is the finding that cortisone, and ACTH to a lesser extent, affect a diminution in the synthesis of antibody globulin in immunized rabbits. Neither of the hormones seems to depress anaphylaxis in the guinea pig, although the tuberculin delayed type of allergic reaction is definitely inhibited both in animals and human beings, and this is reminiscent of the dramatic effects of these drugs in suppressing the acute symptoms of rheumatic fever and rheumatoid arthritis. These effects may be attributed to the capacity of the adrenal cortical hormones to suppress inflammatory tissue reactions. However, this depression, coupled with a similar effect on antibody production and wound repair, permits the characterization of the action of cortisone as a "double-edged sword."

The individual contributions to this symposium are clearly presented and well written. The bibliographic material is extensive. As a succinct summary of currently available knowledge in this field, this symposium deserves careful study by all students of biology.

ABRAHAM G. OSLER

USE OF ANTIBIOTICS IN TROPICAL DISEASES. *Ann. N. Y. Acad. Sci., Vol. 55, Art. 6. Edited by Roy Waldo Miner; Consulting Editor, H. W. Brown. The New York Academy of Sciences, New York.* $4.00. Pp. 967–1284 + 1 pl.; text ill. 1952.

This monograph is a collection of some 30 papers given at a Conference held by the Section of Biology of the New York Academy of Sciences in January, 1952. It summarizes and brings up to date the results of various trials of antibiotics against tropical diseases that have been carried out in different parts of the world. It should be of particular interest to the worker in this field and to the general practitioner. It should also be of help to teachers preparing lectures in a field in which they may not have first-hand information and may wish to bring their lecture material up to date.

DAVID B. TYLER

SYNOVIAL FLUID CHANGES IN JOINT DISEASE. *By Marian W. Ropes and Walter Bauer. Published for The Commonwealth Fund by the Harvard University Press, Cambridge.* $4.00. xvi + 150 pp. + 1 pl.; text ill. 1953.

In the hope that joint fluids might supply information about the nature of joint diseases and might even disclose criteria for the differentiation of various arthritides, a study of such fluids was undertaken and the results are reported in this book. This report is based on the analyses of specimens obtained from normal joints and from 1500 pathologic joints. The studies include observations on physical characteristics such as viscosity

and cytology, immuno-bacteriologic content and chemical analyses on such components as albumin, globulin, mucin, fibrinogen, sugars, non-protein, nitrogen, uric acid, and electrolytes. The differences in nature of the specimens permitted the establishment of two groups. The first group showed no remarkable changes in physical and chemical composition when compared to the normal, and comprises those joints affected by trauma, including osteochondritis dissecans, osteochondromatosis, Charcot joints, and degenerative joints diseases. The second group demonstrated definite changes in the characteristics of the fluid and could be traced to diseases of infectious origin or rheumatic when serologic and bacteriologic reports were positive, but otherwise further pinpointing of the ethiologic factor could not be made with assurance. However, the authors point out that when the analyses of the fluids are used in conjunction with the clinical findings, assistance may be obtained in the differential diagnosis.

The nature of this report is such that it involves lists of figures. These are tabulated to permit rapid recognition of the findings. But thanks to the fact that the text is well written and helps interpret and evaluate the findings, the book is more than a mere repository of statistics. The literature on arthritis is voluminous, yet there has been lacking a coordinated study of the nature of joint fluids. This volume helps cover this deficiency. As the authors indicate, improvements in the methods of analysis make it possible to increase the usefulness of such studies.

I. Wm. Nachlas

Advances in Cancer Research. *Volume 1.*
Edited by Jesse P. Greenstein and Alexander Haddow. Academic Press, New York. $12.00. xi + 590 pp.; ill. 1953.

This volume initiates a new series of *Advances* designed to present reviews by authorities in their respective disciplines, the recent advances in cancer research. The first volume constitutes an excellent beginning. It contains 10 contributions on the following topics: Electronic Configuration and Carcinogenesis (C. A. Coulson); Epidermal Carcinogenesis (E. V. Cowdry); The Milk Agent in the Origin of Mammary Tumors in Mice (L. Dmochowski); Hormonal Aspects of Experimental Tumorigenesis (W. U. Gardner); Properties of the Agent of Rous No. 1 Sarcoma (R. J. C. Harris); Applications of Radioisotopes to Studies of Carcinogenesis and Tumor Metabolism (Charles Heidelberger); The Carcinogenic Aminoazo Dyes (James A. Miller and Elizabeth C. Miller); The Chemistry of Cytotoxic Alkylating Agents (W. C. J. Ross); Nutrition in Relation to Cancer (Albert Tannenbaum and Herbert Silverstone); and Plasma Proteins in Cancer (Richard J. Winzler). The indexing, both author and subject, is very adequate. Undoubtedly, this series should prove a valuable addition to the libraries not only of those engaged in cancer research but of others in a large number of the various disciplines that contribute to this general subject.

David B. Tyler

Forensic Medicine. *Second Edition.*
By Keith Simpson. The Williams & Wilkins Company, Baltimore. $4.50. viii + 344 pp. + 2 pl.; text ill. 1952.

This short textbook is designed primarily for the general practitioner and the lawyer when their practices bring them in contact with the law and medicine, respectively. It is replete with many interesting and gory illustrations. The first chapter is particularly fascinating in that its subheading is "What to do with a dead body," and Fig. 1, showing the trussed up body of an elderly woman found shut in a trunk, is headed "Disposal of body causing suspicion." Similarly, Fig. 2, a picture of a girl killed by multiple stab wounds with the knife left in her breast, is captioned "Injuries arousing suspicion." Despite this, the book is an authoritative treatise on forensic medicine, and is highly recommended for those whose business makes them concerned with this problem, as well as for authors of the Micky Spillane school.

David B. Tyler

Clinical Diagnosis by Laboratory Methods. *A Working Manual of Clinical Pathology. Twelfth Edition.*
By James Campbell Todd, Arthur Hawley Sanford, and Benjamin B. Wells. W. B. Saunders Company, Philadelphia, and London. $8.50. xii + 998 pp.; ill. 1953.

In the twelfth edition of this "bible," a new coauthor is introduced. This revision contains very few changes from the preceding version, and those are confined to the chapters on the urine and the blood. The chapters on Bacteriological Methods and on Serological Tests for Syphilis have been rearranged and brought up to date to conform with the current nomenclatures and recent modifications as suggested by Bergey's *Manual of Determinative Bacteriology* and the information pamphlets issued by the U. S. Public Health Service.

David B. Tyler

Diseases of the Nervous System *Described for Practitioners and Students. Seventh Edition.*
By F. M. R. Walshe. The Williams & Wilkins Company, Baltimore. $5.50. xvi + 365 pp. + 25 pl.; text ill. 1952.

This is the seventh edition of a very well-known textbook by an internationally prominent figure in clinical neurology. It is not intended to be a comprehensive or scholarly treatise, but rather a selective presentation of that material considered to be of the greatest practical value for students and practitioners. The first half of the book, dealing with some of the anatomic principles underlying diagnosis, is superior to the last half, which briefly discusses certain clinical neurologic pictures. From the point of view of brevity and lack of unnecessary complication, the book will be likely to recommend itself to beginning students.

R. G. GRENELL

PSYCHOLOGY AND ANIMAL BEHAVIOR

CURRENT TRENDS IN THE RELATION OF PSYCHOLOGY TO MEDICINE.

By Wayne Dennis, Robert H. Felix, Carlyle Jacobsen, Robert A. Patton, Yale D. Koskoff, Paul E. Huston, Nathan W. Shock, and Hans J. Eysenck. University of Pittsburgh Press, Pittsburgh. $3.75. x + 189 pp. 1950.

This volume is the fourth in a series which reports conferences at the University of Pittsburgh on current trends in psychology. The relation of psychology to medicine is discussed here from the point of view of common research problems, common problems in professional service, and common problems in the education and training of professional personnel. While the topics covered under these three viewpoints are by no means a complete list of the actual problems that exist, they do represent the major areas in which psychology and medicine interact and have grounds for cooperation.

Following a general chapter on the basic kinship between psychology and medicine, six areas of endeavor common to psychology and medicine are discussed: (1) public health, (2) medical education, (3) experimental psychopathology, (4) neurological research, (5) psychiatry, and (6) gerontology. The seventh and last chapter summarizes the same problems as they come up in England.

All the discussions are necessarily quite general, all emphasize the grounds for cooperation between psychology and medicine rather than the grounds for conflicting interests, and all are written much more from the point of view that psychology can be of very great help to medicine rather than the contrary. Perhaps the past, present, and future contribution of medicine and medical research to psychology is too obvious to need emphasis.

ELIOT STELLAR

PSYCHOANALYSIS AS SCIENCE. *The Hixon Lectures on the Scientific Status of Psychoanalysis.*

By Ernest R. Hilgard, Lawrence S. Kubie, and E. Pumpian-Mindlin; edited by E. Pumpian-Mindlin. Stanford University Press, Stanford. $4.25. x + 174 pp.; text ill. 1952.

These five Hixon lectures on "The Scientific Status of Psychoanalysis" were delivered at the California Institute of Technology a couple of years ago. They form an attempt to evaluate psychoanalysis—to perform an intellectual dissection of the body of psychoanalytic method and theory—with the idea of helping to answer questions regarding its status as a science. The three lecturers each attack the problem from a somewhat different point of view. Hilgard deals with experimental approaches to psychoanalysis and psychodynamics in animals and man; Kubie is concerned with an examination of the fundamental propositions and techniques of quantitation and validation; and Pumpian-Mindlin presents something of a historical analysis, the aim of which is to place psychoanalysis as a science in its "proper" relationship to the biological and social sciences.

Hilgard deals with "efforts to test some of the teachings of psychoanalysis." He beautifully presents the experimental data—with the necessary critical comment and warning—that support certain analytic concepts. He realizes, however, that the available data in large measure relate to the more superficial aspects of the problems involved, rather than to the basic causal factors and interrelationships. It is unfortunate that only at the final page of his second lecture does he come to grips with the precise problem of the prospect of psychoanalysis as a science, and consequently he does not discuss at any length how psychodynamics stands up when examined according to the basic principles of science. Some of this type of discussion appears in the two following lectures, by L. S. Kubie.

Kubie is known to all workers—both clinical and non-clinical—in psychiatry and psychology as one of the most acute critics of psychoanalytic concept and method, as well as for his astute postulation, many years ago, of the role of feedback in these problems and his continuing attempts to understand psychoanalytic concepts in terms of the organization of the brain—attempts to integrate physiological and psychoanalytic theory. In the present discussion his primary purpose has been to search out the areas of psychoanalytic concept and dogma which need help from the exact sciences in order to develop any appreciable degree of precision and to indicate some of the problems involved in the development of "qualitative and quantitative instruments." He outlines many possibilities for fruitful investigation and does not hesitate to suggest that work still remains to be done on such basic psychoanalytic building blocks as free association and transference. To be sure, some of his fundamental tenets can

and should be rigorously questioned—such as his centralization of the symbolic process—but despite one's doubts in certain directions, it is still extremely heartening to see a practicing psychoanalyst search his domain with a not insignificant degree of scientific objectivity.

The book is fascinating and stimulating, and will be of great interest to all human biologists, and other readers who are interested in the problems of scientific method.

R. G. GRENELL

THE PSYCHOANALYTIC STUDY OF THE CHILD. *Vol. VII.*

Managing Editors, Ruth S. Eissler, Anna Freud, Heinz Hartmann, and Ernst Kris; Editorial Assistant, Lottie M. Maury. International Universities Press, New York. $7.50. 448 pp. 1952.

This is the seventh edition of a series dealing with psychoanalytic progress in child study. The editors have included the symposium on The Mutual Influences in the Development of the Ego and the Id which was presented at the Seventeenth Congress of the International Psycho-Analytical Association in Amsterdam (1951). This is an excellent summary of the new Ego psychology. Anna Freud presents an astute evaluation of The Role of Bodily Illness in the Mental Life of Children, and there are studies of the emotional implications of tonsillectomy, and of Separation Anxiety in Mother and Child. Preventive Psychiatry, Preparation of Young Children for Analysis, Learning Difficulties, Aggression and Moral Masochism are some of the topics discussed. The volume comes up to the standard of the previous volumes, and it is recommended to those who want to know what is going on in this field.

J. H. CONN

CHILD PSYCHOLOGY. *College Outline Series.*

By Lester D. Crow and Alice Crow. Barnes & Noble, New York. $1.50 (paper). xv + 267 pp.; ill. 1953.

This volume contains a concise discussion of most of the significant topics dealing with the growth and development of children. There are 14 chapters, chapter tests, and examination questions and answers. The text is keyed to 17 standard textbooks by cross references and a quick reference table. The book is a welcome summary of our current knowledge of child psychology.

J. H. CONN

INTRODUCTION TO EXCEPTIONAL CHILDREN. *Revised Edition.*

By Harry J. Baker. The MacMillan Company, New York. $5.00. xvi + 489 pp. + 16 pl.; text ill. 1953.

This book is intended primarily as a reference book and for use in an introductory course for college students. It is a revision of a text which was published a decade ago, brought "up to date" by the inclusion of new research and the results of recent publications. The present volume has attained the author's goal. It is a carefully selected, unbiased, factual, and brief account of the problems of the physically handicapped. It contains an excellent discussion of the nature of intelligence and the learning process in the slow-learning and in the mentally gifted. The chapter on Neurological and Psychogenic Diseases is concise but fairly inclusive, and there is a well-written discussion of Behavior Adjustment.

J. H. CONN

ADOLESCENT PSYCHOLOGY AND DEVELOPMENT.

By Wendell W. Cruze. The Ronald Press Company, New York. $5.00. xii + 557 pp.; ill. 1953.

The author's goal is "to give a balanced, comprehensive picture of adolescent development in which every aspect of growth is emphasized—physical, intellectual, emotional, moral and social." The book is designed as a textbook for college courses in adolescent psychology. Most of the materials in the book have been used in the classroom. The text is well written and will hold the interest of the average college student. The diagrams and drawings have been carefully chosen. The few pages dealing with the psychoses are too brief to be of any practical value and could have been omitted.

J. H. CONN

PERSONALITY DEVELOPMENT IN ADOLESCENT GIRLS. *Monogr. Soc. Res. Child Develop., Vol. XVI. Ser. No. 53, 1951.*

By Lawrence K. Frank, Ross Harrison, Elisabeth Hellersberg, Karen Machover, and Meta Steiner. Child Development Publications, New Orleans. $4.50 (paper). 316 pp. + 4 pl.; text ill. 1953.

This study is a composite of the results of 5 projective methods (the Thematic Apperception test, the Horn-Hellersberg test, Human Figure drawings, Rorschach, and Graphology). There were 500 subjects. The text includes the 12 pictures used in the Thematic Apperception test and examples of the drawings of each of the other tests made by prepuberal, puberal, and adolescent girls. There is included a series of tables dealing with the age, socio-economic levels, number of siblings, parental origins, and the characteristics in the drawings of various groups. Nine individual protocols are presented in the Appendix. The director of the study (L. K. Frank) acknowledges that the task of obtaining and

interpreting 1500 individual responses was a "prodigious piece of work, much harder and more difficult than anticipated when the study was planned." The results, in general, revealed evidence of more frequent and more severe emotional disturbances in the girls than was anticipated. The subjects in the two younger groups appear to be "unhappy and tense." There is a strong desire to please, implying a lack or a denial of personal desires or interests (in these younger groups). A serious personality distortion was revealed among the girls in the lower economic groups. A pervasive "fear of life" was indicated by prepuberal and puberal girls (in keeping with the Rorschach responses) as well as fear "of growing up," dependency, and reliance on authority. A general fear of sex and a growing concern with the subject's own maturing sexual capacities are revealed in the fantasies and daydreams. It is stated that most adolescent girls exhibit a conflict between acceptance and rejection of the feminine role. Acceptance may mean submission or the beginning of adult life. There is a notable absence, in this study, "of being happy or even satisfied to be feminine and little or no indications of positive expectations of becoming a woman" (p. 203). These are significant findings for those of us who have believed that American girls had by now attained a fair degree of self-acceptance. We apparently have unjustifiably assumed that the girl of today is more assured of her status than she was at the turn of the century. The studies presented in this monograph indicate that there still exists a much greater degree of anxiety than many of us suspected. The monograph is highly recommended to every one who is interested in adolescent behavior.

J. H. CONN

LE CERVEAU ET LA PENSÉE. *Incarnation de l'Esprit. By Jean Lhermitte. Bloud & Gay, Paris.* 320 fr. (paper). 205 pp. + 6 pl. [No date].

In the last few years there seems to have been an even more than usual concern with trying to restate and reassess our ideas concerning the relationship of brain and mind in the light of the observations, findings, and indications of modern scientific experimentation and theory. Mind-body and brain-mind interrelationships have intrigued scholars of all periods since the beginning of recorded science and philosophy. Since Alcmeon it has been generally admitted that the brain is the seat of the mind; Lhermitte asks at the outset if we have progressed much further than this. Although much progress has been made in neurophysiology and psychology, the mechanisms of thought, memory, learning, perception, and consciousness are still indeterminate. As Gerard said, a few years ago, "It remains sadly true that most of our present understanding of mind would remain as valid and as useful if for all we knew the cranium were stuffed with cotton wadding." Lhermitte expresses this general attitude by saying, "Après avoir cru que la science leur livrerait la clef du mystère de notre esprit, les plus qualifiés des savants sont obligés de suspendre leur jugement, d'avouer leur inquiétude et leur perplexité."

This perplexity has led to the formation of many discussion groups as well as to the publication of many volumes, in England, France, the United States, and elsewhere (*The Physical Basis of Mind, Perspectives in Neuropsychiatry, Problems of Consciousness*, etc.). Lhermitte was incited to write the present book by reading these several discussions. He summarizes the current theories according to the views of Le Gros Clark, Brain, Walter, and others, and reviews critically some of the assumptions and problems involved, dealing with cortical structure, bioelectrical activity of the brain, and cerebral mechanics. He raises such questions as whether or not psychological progress can be made by studying the electrical activity of the brain; or whether brain activity is really similar to that of a machine—a question which involves some of the developments in cybernetics of the last few years. Very wisely he makes clear the differences—philosophical at least—between the brain and the machine, which have become confused to some degree in some lay and semiscientific publications. Perhaps he could have said a little more about this mechanical approach. To be sure, there is at the least a reasonable doubt that this approach can ultimately explain certain psychological phenomena, or characteristics such as creativeness, individuality, etc. Nonetheless, it may be able to furnish part of the explanation of some problems of, for example, perception. In addition, it is almost, if not completely, impossible to construct an experimentally (i.e., physiologically) testable theory which includes the psychological factors which one cannot understand or control. Any present physiological brain-mind construct must *begin* on a purely mechanical basis.

Discussions follow of memory, consciousness, and of the possible role of the frontal lobes (effects of lobotomy, topectomy, hemispherectomy, etc.). Too many observations and concepts are involved here to be treated at any length in a review. It is important to note, however, that Lhermitte appears to be somewhat overenthusiastic about the role of the frontal lobes in the dynamics of psychophysiology. In any case, it must be said that a remarkable amount of material has been covered here, and that a great deal of constructive thinking has gone into its presentation. In general, the book will be of great interest to all who work in related fields as well as to those who see and enjoy these basic problems.

R. G. GRENELL

THINKING. *An Introduction to Its Experimental Psychology. By George Humphrey. Methuen & Company, Lon-*

don; John Wiley & Sons, New York. $4.50. xii + 331 pp.; ill. 1951.

Very seldom in contemporary psychology does one find a book as scholarly as Humphrey's work on thinking. Humphrey gives us such an exhaustive account of the earlier work on the experimental psychology of thinking that one is almost tempted to class this book as a volume on a topic in the history of psychology. The careful reader who stays with the author to the end, however, will discover that the careful evaluation of the older literature is for good reason; Humphrey believes that it establishes some fundamental concepts about the nature of thinking.

The best and most detailed part of the book concerns the work of the Würzburg school. Humphrey devotes three long and intensive chapters to the Würzburgers for the reason, apparently, that he regards the establishment of the imageless thought to be a fundamental discovery, and he is also of the opinion that the later work on the directed nature of thinking deals the deathblow to any purely associationistic viewpoint of thinking. Many of Humphrey's readers will dispute this, but for the generation of experimental psychologists that grew up long after the imageless thought controversy died of its own dead weight (the present reviewer belongs to this generation), his arguments will appear refreshing, and perhaps will inspire some to go back and take a second look at this long dormant question.

The chapters devoted to the more recent questions are less adequate, though Humphrey manages to do a very deft job of dissecting the Gestaltist view of thinking In one chapter Humphrey makes use of the clinical data on aphasia to argue for the separation of language and thought, and this section bears careful examination by experimental psychologists who are interested in language and thought.

This is a book for the professional scholar and the advanced graduate student in psychology. Philosophers who have long wondered just exactly how psychologists got to the position they have generally taken about thought will find the book rewarding. Other hardy individuals may wish to dip into this book, but they must be warned that they will find the going difficult. Humphrey's arguments are terse and carefully stated, but he is dealing with matters of great subtilty, and he makes no concessions to popularity. This is an important book, however, and I am willing to wager that twenty years from now graduate students will be working their way through it. This can be said about few books that appear today on the psychological bookshelves.

JAMES DEESE

MENTAL PRODIGIES. *An Enquiry into the Faculties of Arithmetical, Chess and Musical Prodigies, Famous Memorizers, Precocious Children and the Like, with Numerous Examples of "Lightning" Calculations and Mental Magic.*

By Fred Barlow. Philosophical Library, New York. $4.75. 256 pp. 1952.

This little book is chiefly devoted to accounts of the feats and techniques of lightning calculators, "mentalists," and the like. The author presents his material from an undoubted advantage, since he is apparently something of a "mentalist" himself. At any rate, he has made a life-long study of the techniques of mental wizardry.

Much of the material is interesting, and the professional psychologist will find some stimulating ideas. The account is gossipy, however, and reasonably authentic material is mixed in with accounts that would strain the credulity of all but the most gullible. Barlow's theories and interpretations are rather weak, though his discussion of the techniques, particularly of parlor-magic arithmetic, is interesting. Unfortunately, the book will not serve as a scholarly reference on the subject, since much of the material is cited at second-hand, and some important material is missing (for example, Bryan's account of the arithmetical prodigy, Griffith). In general, however, it is a much more restrained treatment than that typically given by non-psychologists to subjects of this sort.

JAMES DEESE

SOCIAL BEHAVIOUR IN ANIMALS, *with Special Reference to Vertebrates.*

By N. Tinbergen. Methuen & Company, London; John Wiley & Sons, New York. $2.50. xi + 150 pp. + 8 pl.; text ill. 1953.

This is another fascinating book about animal behavior from one of the members of the New European school of naturalists who style themselves "ethologists." The extensive observational and experimental work of Lorenz, Tinbergen, and others is treated here in detail. Much of the material, however, is not new, and, indeed, this volume is a little anticlimactic compared with its predecessors.

As in earlier volumes by Tinbergen and others of the same school, there is a strong emphasis upon the role of behavioral adaptation in evolution. Likewise, there is the usual strong emphasis upon the importance of unlearned behavior, an emphasis underscored by the almost complete absence of a discussion of mammalian behavior. Finally, again in company with the earlier books, this volume makes a strong plea for the analytic study of animal behavior under natural conditions. It is this last characteristic, I think, that makes the work of the ethologists as important as it is.

This book is only loosely organized around the topic of social behavior. The problem of interaction between animals is seen primarily as a special case of release-

mechanisms triggering internally primed behavioral patterns.

The present reviewer cannot undertake a detailed criticism of the general type of work presented in this volume. Lehrman, in a recent issue of this journal, has presented such a review. The serious student of animal behavior will want to evaluate this book in the light of Lehrman's rather trenchant criticisms. The work of Lorenz and Tinbergen has now come to the point where it is necessary to examine its weak points as well as admire its great originality.

In conclusion, I would like to mention the enjoyment to be found in reading this little volume. The amateur naturalist and the undergraduate student will find this book as fascinating as it must appear to the professional student of animal behavior. One is occasionally disturbed by the excessively anthropomorphic tone of the descriptive narrative, but this seems to the present reviewer to be largely stylistic. Indeed, the fundamental ideas behind the work of the ethologists are mechanistic and physiological in nature.

JAMES DEESE

HUMAN BIOLOGY

CULTURE: A CRITICAL REVIEW OF CONCEPTS AND DEFINITIONS. *Papers Peabody Mus. Amer. Arch. Ethnol., Harvard Univ., Vol. XLVII, No. 1.*

By A. L. Kroeber and Clyde Kluckhohn, with the assistance of Wayne Untereiner and appendices by Alfred G. Meyer. Peabody Museum, Cambridge. $5.25 (paper). viii + 223 pp. 1952.

Several scholarly fields study man and his works. The psychologist tends to focus on the individual, the sociologist on social structure, the anthropologist on culture. The concept of culture as something beyond the individual and different from society is a major contribution, if not *the* major contribution, of anthropology. However, this concept has had a slow emergence into anthropological consciousness and in the process has had varied definitions and meanings attached to it. These meanings have varied not only with time, but by nation, and even by schools of thought within nations. The authors of this study have brought together the data on how the concept has grown, and the various current definitions. They have discussed the descriptions under the headings of historical, normative, psychological, structural, and genetic types. They then discuss the concept as now defined in its historical and philosophical meaning.

GEORGE F. CARTER

WATER. *A Study of Its Properties, Its Constitution, Its Circulation on the Earth, and Its Utilization by Man.*

By Sir Cyril S. Fox. The Philosophical Library, New York. $8.75. xxvii + 148 pp. + 17 pl.; text ill. 1952.

This book has many items of interest to the non-technical reader on the general subject of water. It is divided into three parts: the first part, The Natural History of Water, deals with its properties, chemical constitution, distribution, and the circulation of water on the earth (the so-called hydrolic cycle); the second part is concerned with the work done by water, and describes the geological aspects of leeching, solvent action and erosion, and sedimentation and precipitation from water. The final part, the Utilization of Water, deals with problems involved in obtaining water supplies from the various natural sources, such as springs, wells, and rivers, as well as the engineering questions of storage reservoirs and the utilization of power from falls. Also, here are discussed the various aspects of the treatment of sewage, the purification of water, desilting, and related projects. There is a good section in the book which deals with many of the land reclamation projects that are being carried out in the United States.

DAVID B. TYLER

WATER. *Miracle of Nature.*

By Thomson King. The MacMillan Company, New York. $3.50. iv+ 238 pp. 1953.

The physical characteristics of water, and the essential functions it performs in geology and the other earth processes, as well as in all living organisms are briefly noted for the layman. The manifold uses of water by man are described, from floating fighting ships and freighters to its use in steam engines, in worship, in irrigation, and for city water supply. A unique book about a unique subject!

ROBERT L. PENDLETON

LAND FOR TOMORROW. *The Underdeveloped World.*

By L. Dudley Stamp. Indiana University Press, Bloomington; American Geographical Society, New York. $4.00. 230 pp.; ill. 1952.

Underdevelopment covers two contrasted views of agricultural efficiency: output per unit area, and output per man-hour. The author rightly emphasizes the need of studying native land-use practices before condemning them and trying to displace them with other methods, however good in mid-latitudes. Equatorial regions are regions of lasting difficulty. Further disappointment should not be invited by undertaking large scale agri-

culture in the tropics. Tropical soils are fragile and their resources much more easily dissipated than those of mid-latitudes. Hence it is so much easier and more certain of success to increase the production of underdeveloped mid-latitude lands than to attempt to use on a large scale the tropical lands. In the meantime, the land use problems of the tropics and the native methods of utilization and crop productior should be studied with due humility. This book should be a requirement for everyone concerned with "Point 4" agricultural projects.

ROBERT L. PENDLETON

AFRICA: A STUDY IN TROPICAL DEVELOPMENT.
By L. Dudley Stamp. John Wiley & Sons, New York; Chapman & Hall, London. $8.50. viii + 568 pp. + 8 folded charts or maps; ill. 1953.

The first two-fifths of this book deal with the continent as a whole, with the emphasis upon Africa between the tropics. This is a less well-known and probably more over-rated portion of the continent. A careful reading of this book should correct many misapprehensions, for the author writes with the convictions of first-hand experience. The second three-fifths of the book treat of the countries and regions of Africa on a regional basis, though these have inevitably been interrupted by national or administrative limits. Moreover, it might have been more logical to describe separately the "European" areas and the native reserves. The treatment of shifting cultivation is good. The book closes with a brief Part 3, a summary of the problems of the continent—past, present, and future. The book is profusely illustrated with many excellent photographs, many of which are aerial. Many text maps and numerous larger, folded maps are included. This is certainly an excellent and up-to-date volume on Africa. It can be heartily recommended.

ROBERT L. PENDLETON

BIOMETRY

THE METHODS OF STATISTICS. *Fourth Edition.*
By L. H. C. Tippett. John Wiley & Sons, New York; Williams & Norgate, London. $6.00. 396 pp.; ill. 1952.

A STATISTICAL PRIMER.
By F. N. David. Charles Griffin & Company, London. 22s. xii + 226 pp.; ill. 1953.

STATISTICAL METHODS FOR CHEMICAL EXPERIMENTATION.
By W. L. Gore. Interscience Publishers, New York, and London. $3.50. xi + 210 pp.; ill. 1952.

For the research worker, chemical, medical, or biological, there is no shortage of good manuals on statistics. About twenty-five years ago only a handful of books was available. Today one publishing house alone has more than two dozen monographs dealing with statistics and their application. The three books listed above are fairly representative of recent contributions in this field.

The Methods of Statistics, by Tippett, is a new edition. It is essentially an introduction to statistics, maintaining the general features and characteristics of a previous edition published 17 years ago. It requires of the reader a fair knowledge of mathematics and, for complete understanding, a systematic reading of the book from the first to the last chapters. Applications of analysis of variance are dealt with in considerable detail. The design of experiments is not as fully treated as in Gore's little manual, and no mention is made of factor analysis.

A Statistical Primer, by David, is designed for those who wish to learn something about the elements of statistics but have little or no knowledge of algebra. The illustrations are selected with care and the uninitiated should have no difficulty in acquiring some of the statistical terms employed. However, the work is definitely not intended for anyone with some mathematical background.

Gore's book, *Statistical Methods*, differs somewhat from the others in that it stresses the principles of designing experiments, to which subject some 60 pages are devoted. The manual presents very clearly the methods most commonly employed in statistical work and does not require a knowledge of the mathematics of probability. It is primarily designed for chemists, but it should be very useful for research workers in the biological and medical disciplines as well.

DAVID B. TYLER

METHODS OF STATISTICAL ANALYSIS. *Second Edition.*
By Cyril H. Goulden. John Wiley & Sons, New York. $7.50. vii + 467 pp.; ill. 1952.

The author has done an admirable job of revising his first edition to include some of the more recent developments in statistical methods. In many respects the book bears little resemblance to its predecessor, and for the most part the changes are commendable. Discriminant functions, errors of the second kind, and fractional replication are just a few of the new topics which have been incorporated and which are not often found in elementary texts. On the other hand, one might argue that the inclusion of such topics necessarily removes the book from the realm of elementary statistics. The author indicates only that his "subject matter is slanted rather definitely towards the needs of the student who is now, or will eventually be, a research worker." He

does not state whether he feels that the textbook can be used profitably for a first course in statistics.

The reviewer received two very definite impressions which may or may not reflect the intent of the author. He has made a definite attempt to provide the reader with more of a logical foundation and understanding of the basic ideas than can be found in most texts on applied statistics. To achieve this end he has introduced methods from algebra, matrix theory, and calculus which are occasionally needed in the development, but which must be taken on faith if the reader is unfamiliar with them. The author must be applauded for attempting to lay a firm foundation for his subject even though some students may be lost or befuddled because of inadequate mathematical preparation. The second impression was that the author has been overly ambitious by attempting to cover a wide range of subjects at the necessary expense of treating some of them rather inadequately. In this category are covariance analysis, sequential analysis, quality control, and the use of transformations in the analysis of variance.

There are a few recent developments which, had they been included, would have provided a better balance in some chapters. In keeping with his desire to lay the proper groundwork, Goulden might have described more fully the analysis of variance models and have pointed out the properties of homoscedasticity and independence which are so basic to proper use and interpretation. In this connection, the estimation of variance components perhaps deserved more attention than it was given. In the chapter on goodness of fit, some reference to tests based on the work of Kolmogorov and Smirnov might have been included. Other authors have shown these tests to be superior to chi-square tests in many situations.

On the whole, the advantages of the revised edition far outweigh its shortcomings. The student or research worker who completes a study of this text will have a much better understanding of basic statistical ideas and how to use them than will the person who studies most other texts on first principles. Although the average mortality rate will probably be higher, the final student product has an excellent chance of being superior.

A. W. KIMBALL

ELEMENTS OF STATISTICS.

By C. G. Lambe. Longmans, Green & Company, London, New York, and Toronto. $1.75. viii + 112 pp.; ill. 1952.

In the Preface the author states that he has attempted "to produce a working textbook of a practical nature." It was written "primarily for the use of engineering students," but he hopes it will be useful to "scientists and experimentalists of all kinds." If this volume had appeared 35 years ago, the author's objectives might have been fulfilled, but today, with the contributions of Fisher, Neyman, Pearson, and others firmly established, it would be unfortunate indeed if a new student were introduced to the subject through this medium. The book is well written, and I could find no errors except those of omitting the very tools of statistics which would make it most useful to scientists and experimentalists.

Included are brief chapters on frequency distributions, statistical measures, probability distributions, correlation, theory of errors, and quality control. Tests of significance are almost completely ignored. Although the author refers to the design of experiments and determination of sample size in his introduction, little or no mention of these important topics can be found in the text. Other basic topics which have been omitted are the uses of chi-square, the analysis of variance, and and confidence interval estimation. All of these are important even in elementary applications to scientific research.

The text is short, and in fairness to the author the possibility must be admitted that he was attempting to cover certain basic statistical ideas as a foundation for future study by students encountering statistics for the first time. Yet such attempts have been made before and, as most statistical educators know, this approach usually introduces more confusion than it eliminates. The unfortunate fact is that most students cannot assimilate enough statistics in a one quarter or one semester course to do them any real good.

A. W. KIMBALL

THE DESIGN AND ANALYSIS OF EXPERIMENT.

By M. H. Quenouille. Hafner Publishing Company, New York. $7.50. xiii + 356 pp.; ill. 1953.

With the publication of this book, M. H. Quenouille has made another commendable addition to the rapidly increasing body of statistical literature. The field of experimental design is covered quite thoroughly, and many points which are inherently difficult to explain have been presented with exceptional clarity. I must, however, disagree with the author with respect to the statistical level at which the book is written. In his introductory chapter, he has devoted 1½ pages to a "brief summary" of "certain statistical methods and terms" which are used in the rest of the book. He implies that this should be sufficient for "those wishing to avoid any deeper contact with statistical methods." Whether he intended this to mean that a research worker would need no additional knowledge of statistics in order to profit from the book is not clear. The truth is that very few readers who are being exposed to statistics for the first time will be able to benefit from it. Some acquaintance with elementary statistical procedures is a prerequisite to its use. Another aspect of the book, which detracts only slightly from its usefulness, is that all of the examples are either biological or agri-

cultural. This can be explained in part by the paucity of appropriate applications in other fields of scientific research.

Certain features of the text are worth special mention. Chapter 1, which among other things discusses the choice of a design, includes a table which classifies the most useful designs and gives their properties. This table, and the one in Chapter 8 which lists incomplete block designs and their relative merits, provide the experimenter with a quick reference for choosing a suitable design. Chapter 2 includes a discussion of the method suggested by Tukey (*Biometrics*, 5: 99. 1949) for separating means in an analysis of variance. Although recently this method has to some extent been superseded by more exact procedures, it is notable that the author tackles the problem at all. Many books ignore it completely. In Chapter 3, which introduces the factorial design, the author emphasizes that one of the main features of this type of design is its ability to evaluate interactions, and his development follows this pattern. Chapter 7 contains a good discussion of fractional replication of factorial designs, although the material presented would prove inadequate for an experimenter who actually wanted to use one. The often neglected problems of long-term experiments and combining results from different experiments are handled admirably in Chapters 9 to 11. In one section the use of rank analysis is discussed. Special topics such as cross-over designs, sequential experimentation, and missing observations are considered in Chapters 12 and 13. Finally, in Chapter 14, the general problem of scaling and, in particular, the use of transformations to achieve homogeneity of variance or approximate normality are treated at some length. A carefully selected bibliography is appended.

As a comprehensive treatment of modern experimental design, the book is highly satisfactory. Very little has been omitted. As a textbook for students or as a tool for research workers, it suffers mainly from the lack of computational details, particularly with respect to the more complicated designs. In these cases references are given which allegedly fill the gap, but the reader should not be surprised if some of them fail to provide him with what he needs. On the other hand, one might argue that most experimenters would not attempt to use one of the more difficult designs without the personal advice of a statistician, and that to have augmented the computational details would have served no purpose. In spite of any criticism, the book is a well-integrated piece of work and should serve both student and experimenter adequately for most purposes.

A. W. KIMBALL

SAMPLING TECHNIQUES.

By William G. Cochran. John Wiley & Sons, New York; Chapman & Hall, London. $6.50. xiv + 330 pp.; ill. 1953.

Sampling Techniques is a truly worthwhile and badly needed addition to the statistical literature. Although sample surveys have been conducted for many decades, only in recent years have statisticians developed the theory of sampling into an organized well-founded discipline. Before World War II, very little of modern statistical theory could be found in book form. After the war, due in part to the efforts of a few publishers, there was a rapid rise in the number and quality of statistics textbooks dealing with both theory and applications. Now, with the appearance of *Sampling Techniques*, almost every major field of statistics is well represented in textbook form.

The author needs no introduction to statisticians and should be familiar to most biologists as co-author with Gertrude M. Cox of *Experimental Designs*, almost a necessity for any conscientious experimenter. In *Sampling Techniques*, the author's former students will recognize the extremely lucid and logical method of presentation which has always characterized his lectures. Cochran's philosophy with regard to the teaching of statistics is described clearly in this quotation from the preface:

"By the use of powerful operation methods, the bulk of existing theory can now, I believe, be developed in a very compact space as particular cases of a few general results. Such a development would be illuminating in clarifying the interrelationships between the different parts of the subject, and might prove a stimulus to further research and discovery. But my experience in teaching has been that most students who wish to learn something about sampling theory find this kind of presentation heavy going, and prefer a more leisurely progress."

In this matter most readers will agree with the author. For a reasonable understanding of the proofs, familiarity with algebra and with parts of the calculus is necessary, although the author discusses many points which can be understood without a mathematical background.

Separate chapters have been devoted to simple (or unrestricted) random sampling, sampling for proportions or percentages, stratified random sampling, systematic sampling, subsampling (with units of equal or unequal size), and double sampling. In another chapter the problem of estimating sample size is considered, and an approach to its general solution is proposed. In the two chapters on ratio estimates and regression estimates, the author illustrates how the accuracy of some sample surveys may be increased by observing a second variable which is correlated with the principal variable under study. The final chapter is devoted to an analysis of the errors in sample surveys. Numerous exercises varying in difficulty are found at the end of each chapter along with references to pertinent literature. Answers to the exercises are given in the back of the book. Separate author and subject indexes have been provided.

Except for its clarity of presentation, the book's most

outstanding characteristic is its strict adherence to the practical needs of survey statisticians regardless of the theoretical difficulties which are encountered. Unfortunately, in statistics it is often the simplest and most important questions which are the hardest to answer. W. G. Cochran has a knack of finding good approximate methods for handling difficult problems which many of us would not even tackle. As a result, the practicing survey sampler can expect to find some sort of answer to most of his problems. In cases where no answer is available, the reader is so informed and is not left to guess for himself.

The author hopes "that the book will be useful both as the basis of a course on sample survey techniques in which major emphasis is on theory, and for individual reading by the student who does not have access to formal instruction." Although the emphasis is on theory, the manner in which it is presented would allow the book to be used as a textbook in a course on applications provided that it was supplemented with sufficient illustrative material. Conceivably, the author could have incorporated the necessary additions into this volume, only however by lengthening it considerably. Even lacking this modification, *Sampling Techniques* should prove to be a major tool both for theorists and for practitioners for many years to come.

A. W. KIMBALL

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

A POLICY FOR SCIENTIFIC AND PROFESSIONAL MANPOWER. *A Statement by the Council with Facts and Issues Prepared by the Research Staff, National Manpower Council.*

National Manpower Council. Columbia University Press, New York. $4.50. xxii + 263 pp.; ill. 1953.

The National Manpower Council was established in 1951 at Columbia University with support from the Ford Foundation. Its first report on Student Deferment and National Manpower Policy was published in 1952. The present volume is the second report to be issued by the Council. The report calls attention to a need of more reliable knowledge regarding our human resources and urges a cooperative effort on the part of foundations, universities, and the Federal Government to learn more about these resources and the reasons for career choices. It calls for a strengthening of educational institutions through increased financial support both by state and private agencies. It also calls for a presidential commission to study the impact of governmental research and development contracts on college and university programs in basic research and on the training of scientists and scholars. It urges support for the present program of student deferment and calls for a more flexible policy regarding the calling of ROTC enrollees to active duty, to permit them to undertake graduate work prior to their military service. It recommends more interest and emphasis on good elementary and secondary education and better counselling; and it advocates public scholarship and fellowship programs. It further urges that the President initiate a review of existing legislation and administrative procedure relating to the recall of reservists to active duty, with a view to providing civilian participation in the determination of relative military and civilian needs for scientific and professional personnel.

While the recommendations contained in the report make sense on the whole, it is important to point out that the volume deals almost entirely with the physical sciences and engineering. Only medicine and nursing from the life science field are given any consideration. That manpower problems exist in the biological sciences is completely ignored. It will be unfortunate, indeed, if, in future considerations regarding manpower needs, the importance of biologists to the nation and the necessity of ensuring an adequate flow of trained biologists is overlooked. The National Manpower Council has displayed in this report a monumental blind spot so far as the basic biological sciences are concerned.

RALPH E. CLELAND

GENERAL CHEMISTRY. *An Elementary Survey Emphasizing Industrial Applications of Fundamental Principles. Sixth Edition.*

By Horace G. Deming. John Wiley & Sons, New York; Chapman & Hall, London. $5.75. xii + 656 pp. + 6 pp. of logarithmic tables; text ill. 1952.

The success of a textbook which has reached its sixth edition speaks for itself. This latest edition, 29 years after the original publication, has a number of new aids for students. These include summaries at the ends of many of the chapters, scattered questions throughout the early chapters, and exercises at the end of each chapter. More emphasis has been placed on nuclear structure, and less detailed treatment is devoted to topics that are primarily of interest to engineers.

ALVIN NASON

INTRODUCTION TO ELECTRON MICROSCOPY.

By Cecil E. Hall. McGraw-Hill Book Company, New York, Toronto, and London. $9.00. x + 451 pp.; ill. 1953.

The past three decades have witnessed the growth of the electron microscope from theoretical discussions in the twenties, through experimental models in the thirties, to commercial production in the forties. Now so perfected as to be essentially out of the hands of the physicists, it is capable of extending our powers of visualization as far beyond the light microscope as the light microscope extended resolution beyond the powers of

the naked eye. For nearly a decade, a full use of the electron microscope by biologists was hampered by the limited penetrating power of the electron beam. Unlike light, which readily penetrates a 10μ section, the electron beam requires a specimen not more than 0.1μ thick to produce an adequately resolved electron micrograph. In response to this requirement ultramicrotomy and fixation techniques were developed, chiefly since 1948. Now adequately thin sections of properly fixed tissues are being routinely prepared in many biological laboratories. It is not an exaggeration to say that instrumentation is now available which enables the biologist to see structures only one hundredth the diameter of the smallest particles resolved by the light microscope. The individual points of detail in electron micrographs are 10,000 times as numerous as those upon which the scientific disciplines derived from light microscopy are now based.

Numbers of books have been written about the electron microscope, but these have usually put emphasis on some particular phase of the subject, and consequently have limited usefulness. In the present text general theory is evenly balanced with practical application. It is intended for the practical electron microscopist, and is the finest yet to appear. Beginning with an unusually lucid explanation of the elements of physical theory, it progresses to the behavior of electron beams in electric and magnetic fields (the "lenses") and describes the way these principles are utilized in the assemblies of an electron microscope. Later chapters on scattering phenomena and image characteristics describe the essential nature of the electron micrograph, from which the final analysis must be made. Commercial microscope models and current methods of preparing specimens are described. The last chapter illustrates and discusses examples of applied electron microscopy.

The proper use of both the light microscope and the electron microscope requires some knowledge of background theory. For example, certain characteristics of the electron microscope, such as focusing phenomena and the relationship of resolution and depth of field to specimen thickness, are expressed in electron micrographs. This occurs in such a way that certain criteria used for the interpretation of light micrographs are no longer valid. Both the investigator using an electron microscope and the reader interpreting published electron micrographs must be aware of these, since they are responsible for the deceptive similarity of light and electron micrographs. Some interpretative errors now common might have been avoided by familiarity with the principles so well described in this book.

The electron microscope is one of the most remarkable research tools developed in this century. It has opened the door to investigative fields in biology and medicine too vast even for speculation. It is therefore well to realize, while the instrument is still young, the need for learning the special characteristics that determine its abilities and limitations. As a source written at a level neither easy nor too difficult for the biologist, Hall's *Introduction to Electron Microscopy* is recommended without reservations.

F. N. Low

STEDMAN'S MEDICAL DICTIONARY. *Eighteenth Revised Edition.*

Edited by Norman Burke Taylor, in collaboration with Allen Ellsworth Taylor. The Williams & Wilkins Company, Baltimore. $11.50. xliv + 1562 pp.; ill. 1953.

To this edition of Stedman's several thousand new words have been added. This, in a way, may be a measure of the progress made in the medical sciences since the 17th edition of this dictionary was published in 1950 (*Q.R.B.*, 25: 127. 1950)—if progress in the medical sciences can be related to the creation of new medical words. However, such new babies must give the lexicographers many sleepless nights. It is a constant source of amazement that they are not completely confused by new technical terms created by those who have no regard for the rudimentary rules of etymology. It has been sensibly suggested that some association or academy composed of classical scholars (as well as medical men) be formed to serve as a philological authority. Such an agency undoubtedly might do a lot to prevent "etymological miscegenations" between English or French roots and those of Latin and Greek, or, what is worse, the living in sin of a Greek with a Latin. In this way, they could do much to prevent the birth of so many of the unlovely, bastard hybrids that plague the editors of any new medical dictionary.

DAVID B. TYLER

GERMAN-ENGLISH MEDICAL DICTIONARY.

By Louis De Vries. McGraw-Hill Book Company, New York, Toronto, and London. $12.00. x + 586 pp. 1952.

This dictionary is primarily designed for those whose college German has been long forgotten. It contains approximately 40,000 entries and incorporates many word forms and idioms which should be quite helpful.

DAVID B. TYLER

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION, *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1951.*

The Smithsonian Institution, Washington. $3.00. ix + 449 pp. + 68 pl.; text ill. 1952.

This volume contains the following articles of biological interest, all but the last one reprinted from other

scientific journals: Enzymes: Machine Tools of the Cellular Factory (B. A. Kilby); The Fauna of America (Austin H. Clark); The Mechanics of Snakes (Alfred Leutscher); Hormones and the Metamorphosis of Insects (V. B. Wigglesworth); Utilizing our Soil Resources for Greater Production (Robert M. Salter); The Carbon-14 Method of Age Determination (Frank H. H. Roberts, Jr.); River Basin Surveys: The First Five Years of the Inter-Agency Archeological and Paleontological Salvage Program. These meritorious collections of well written and interesting general articles, many of which are excellently illustrated, continue to offer the most for the money to those who like general scientific reading of high-grade authoritativeness yet not too technical in nature.

CARNEGIE INSTITUTION OF WASHINGTON YEAR BOOK NO. 51. *July 1, 1951–June 30, 1952. With Administrative Reports through December 12, 1952.* *Carnegie Institution of Washington, Washington* $1.50 (cloth). $1.00 (paper); xxxv + 286 pp.; ill. 1952.

In this *Year Book* the reports of the three biological departments of the Carnegie Institution occupy 135 pages, apportioned among the Department of Plant Biology (60 pp.), Department of Embryology (24 pp.), and Department of Genetics (51 pp.). The report in Plant Biology covers work in experimental taxonomy, especially *Poa* and *Achillea* hybrids and cytology, biochemical and physiological investigations with *Chlorella* and *Scenedesmus*, and paleobotany. The work in Embryology includes morphological studies of early human embryos, experimental studies on sex development and sex transformation in opossum embryos, an investigation of fetal circulation, and studies of uterine muscle physiology. In Genetics varied programs encompassed work on mouse leukemia, bacterial genetics, the bacteriophage life cycle and recombination, mutable loci in maize, enzymatic studies of chromosome organization and the biochemistry of nucleic acids. Biologists working in any of these or allied areas have long since learned to scan the pages of the *Carnegie Year Book* carefully in order to glean the preliminary reports, and sometimes the only reports, of significant advances.

Annals of Human Genetics

(FORMERLY ANNALS OF EUGENICS)

Edited by L. S. PENROSE *with the assistance of*

JULIA BELL, R. A. FISHER, J. B. S. HALDANE, MARY N. KARN, R. R. RACE, J. A. F. ROBERTS

Vol. XIX. Part 1. July 1954.

The Pelger-Huët Anomaly. Investigation of Family "A". A. G. ACKERLEY, W. A. DAVISON, & SYLVIA D. LAWLER.

The distal triradius *t* on the hands of parents and sibs of mongol imbeciles. L. S. PENROSE.

Notes on sickle-cell polymorphism. A. C. ALLISON.

With Appendix to notes on sickle-cell polymorphism. SHEILA MAYNARD SMITH.

Effect of age and parity of the mother on the birthweight of the offspring. JEAN MILLIS AND Y. P. SENG.

Reviews

SUBSCRIPTION (payable in advance) *$9.50 per volume of 4 parts.*

NEW ISSUES OF THE GALTON LABORATORY
EUGENICS LABORATORY PUBLICATIONS—MEMOIR SERIES

XXXVI Race crossing in Man. The Analysis of Metrical Characters. By J. C. TREVOR, Ph.D. Price $2.50.

XXXVII An Introduction to Human Biochemical Genetics. By H. HARRIS, M.D. Price $2.75.

***Issued by the* CAMBRIDGE UNIVERSITY PRESS**

32 East 57th Street, New York 22, N. Y.

ECOLOGY

Official Publication of the ECOLOGICAL SOCIETY OF AMERICA
Continuing the Plant World

Editors:

Edward S. Deevey (Zoology), Yale University — **W. D. Billings** (Botany), Duke University

Vol. 35, No. 3 — *CONTENTS* — July 1954

The hydrobiology of Atwood Lake, a flood-control reservoir ..... *John C. Wright*
An analysis of the spruce-fir community on the Kaibab Plateau, Arizona ..... *John Merkle*
Factors controlling the distribution of oysters in a natural estuary ..... *Nelson Marshall*
Evidence of four pine species from fossil pollen in Michigan ..... *John F. Grayson*
Quantitative studies of protozoan populations from two areas of Pymatuning Lake, Pennsylvania ..... *Howard D. Orr*
Ecology of the Opuntine in the Big Bend region of Texas ..... *Margery Anthony*
Cell contents of nitrogen and phosphorus as a measure of their availability for growth of *Microcystis aeruginosa* ..... *Gerald C. Gerloff and Folke Skoog*
Climates of the Great Smoky Mountains ..... *Royal E. Shanks*
Equations descriptive of fish schools and other animal aggregations ..... *C. M. Breder, Jr.*
Soil phosphate and the delimitation of plant communities in eastern Australia ..... *N. C. W. Beadle*
The ecological distribution of the *Peromyscus leucopus* species group in eastern Texas ..... *W. H. McCarley*
Soil mantle movement in relation to forest clearing in southeastern Queensland ..... *Lincoln Ellison and J. E. Cooldrake*
Mortality rates of whitefish in an arctic lake ..... *Donald E. Wohlschlag*
The influence of shade and litter of pine on evaporation from a clay loam soil at Berkeley, California ..... *Joseph Kittredge*
Ecological studies of forest trees at Chalk River, Ontario, Canada. I. Tree species in relation to soil moisture sites ..... *Donald A. Fraser*

NOTES AND COMMENTS — REVIEWS

Orders should be placed with
Duke University Press
College Station — Box 6697 — Durham, North Carolina

(In writing to advertisers, please mention the journal—it helps.)

SANS TACHE

The book to read

before you write . . .

153 pp.

9 figs.

$1.50

· AUTHOR · PUBLISHER · PRINTER ·

COMPLEX

By Robert S. Gill

SECOND EDITION

Contents. . .

The Concepts Printing and Publishing
Purpose and Plan of This Book • Printing and Publishing: A Contrast • The Publisher's Function • When Is a MS Publishable?

The Author and Printing Processes
First Stage • Second Stage • Third Stage

Form Suitable
What the Publisher Hopes to Find • Causes of Form Not Suitable • Final Reading • Verbal Bums

Fair Copy
The Typescript • Headings and Subheadings • References • Legends, Footnotes, Bibliography • Consistency • Quotations • Permissions • Punctuation • Phrases to Avoid • Pagination • Correction of MS • Three Useful Tools

Illustrations
Some Unnecessary Procedures • Graphs and Charts • Half-Tones • X-ray Film or Print • Color • Plates • Grouped Illustrations • Reduction • Clippings, Borrowings, Permissions • Legends • Numeration • Final Reading

The Ends and the Oddments
The Minor Prelims • Preface and Foreword • Table of Contents • Supplementary Lists • Bibliography • Other Incidentals • The Index

The Reading of Proof
Exchange of Proof • Authors' Alterations • Galley-Proof • Proofs of Illustrations • Page-proof

Revision
Errata • Reprinting • General Remarks on Revise • Revise, No Type Standing • Revise from Standing Type • Revise from Electroplates

Literary Property and Inheritance
Property-right and Copyright • Literary Inheritance • Literary Successorship • Literary Heir • Publishing Agreement and the Author

Royalties and Such
Bases of Royalty • Sliding Scale • When Is a New Edition? • Remainder Clause • Author's Copies • Royalty Payments

The Author as Co-Publisher

THE WILLIAMS & WILKINS COMPANY
Mt. Royal and Guilford Aves. Baltimore 2, Maryland

(In writing to advertisers, please mention the journal—it helps.)

THE QUARTERLY REVIEW OF BIOLOGY publishes critical reviews of recent researches in all of the special fields of biological science. The contribution should present a synthesis or digest of the researches and a critical evaluation of them. A mere synopsis of the literature without evaluation or synthesis is not desirable.

Theoretical papers are published occasionally, especially when such papers (1) include a critical synthesis of the literature bearing on the theory and (2) are likely to promote further research in a given field.

The article should be written in concise language, yet in sufficiently non-technical form as to be intelligible not only to specialists in other fields but to the general biologist as well. To this end the article should have a general introduction and a summary which enumerates one by one all of the principal facts and conclusions given in the paper. Interpretative diagrams and schemes are very desirable.

Material ordinarily taking the form of footnotes is set in small print and placed in the text and consequently should be written in a style so as to fit readily into the text. Acknowledgments are printed in the text in small type at the end of the article just preceding the List of Literature. Recent issues of the Quarterly should be examined for style as regards (1) section or subsection headings in the text, (2) literature citations in the text, and (3) List of Literature.

The subjects and authors of articles are selected by the Editors and members of the Advisory Board. Unsolicited articles which conform with the objectives of the Quarterly will be considered for publication.

A feature of the REVIEW is the section dealing with *New Biological Books*. In this department the book literature of different countries in the field of Biology is given prompt notice.

The QUARTERLY REVIEW OF BIOLOGY is issued in March, June, September and December.

Twenty-five reprints, with covers, of articles will be furnished to contributors free of cost. The reprint order blank accompanying galley proofs gives the cost of additional reprints.

Manuscripts may be sent to Dr. B. H. Willier, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

Books for Review may be sent to Dr. H. B. Glass, Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland.

New subscriptions and renewals are entered to begin with the first issue of the current volume. Should any issue of the current volume be out of print at the time the subscription order is received, the pro-rata value of such numbers will be refunded to the subscriber.

Subscriptions should be renewed promptly—To avoid a break in your series, subscriptions should be renewed promptly. The publishers cannot guarantee to supply back issues on belated renewals.

Subscription price: $6.00 United States and countries within the Postal Union; $6.50 countries outside the Postal Union. Single copies will be supplied, when available, at the rate of $1.75 a copy.

Claims for copies lost in the mails must be received within 30 days (domestic).

Changes of address—Publisher must be notified 60 days in advance. Journals undeliverable because of incorrect address will be destroyed. Duplicates can be obtained (if available) from the publisher at the regular price of single issues.

THE WILLIAMS & WILKINS COMPANY

Publishers of Scientific Books and Periodicals

BALTIMORE, U. S. A.

CONTENTS

The Population Consequences of Life History Phenomena
—*LaMont C. Cole* (103–137)

New Biological Books
The Premedical Curriculum
—*C. P. Swanson* (138–141)

Reviews and Brief Notices (141–206)